# Basler scout light

## USER'S MANUAL FOR SCOUT LIGHT GigE VISION CAMERAS

Document Number: AW001047
Version: 01  Language: 000 (English)
Release Date:  30 November 2011

BASLER

**For customers in the U.S.A.**

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

You are cautioned that any changes or modifications not expressly approved in this manual could void your authority to operate this equipment.

The shielded interface cable recommended in this manual must be used with this equipment in order to comply with the limits for a computing device pursuant to Subpart J of Part 15 of FCC Rules.

**For customers in Canada**

This apparatus complies with the Class A limits for radio noise emissions set out in Radio Interference Regulations.

**Pour utilisateurs au Canada**

Cet appareil est conforme aux normes Classe A pour bruits radioélectriques, spécifiées dans le Règlement sur le brouillage radioélectrique.

**Life Support Applications**

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Basler customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Basler for any damages resulting from such improper use or sale.

**Warranty Note**

Do not open the housing of the camera. The warranty becomes void if the housing is opened.

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# 1 Specifications, Requirements, and Precautions

This chapter lists the camera models covered by the manual. It provides the general specifications for those models and the basic requirements for using them.

This chapter also includes specific precautions that you should keep in mind when using the cameras. We strongly recommend that you read and follow the precautions.

## 1.1 Models

The current Basler scout light GigE Vision camera models are listed in the top row of the specification tables on the next pages of this manual. The camera models are differentiated by their sensor size, their maximum frame rate at full resolution, and whether the camera's sensor is mono or color.

Unless otherwise noted, the material in this manual applies to all of the camera models listed in the tables. Material that only applies to a particular camera model or to a subset of models, such as to color cameras only, will be so designated.

# 1.2 General Specifications

| Specification | slA640-74gm/gc | slA780-54gm/gc | slA1390-17gm/gc |
|---|---|---|---|
| Sensor Size (H x V pixels) | gm: 659 x 494<br>gc: 658 x 492 | gm: 782 x 582<br>gc: 780 x 580 | gm: 1392 x 1040<br>gc: 1390 x 1038 |
| Sensor Type | Sony ICX414 AL/AQ | Sony ICX415 AL/AQ | Sony ICX267 AL/AK |
| | Progressive scan CCD | | |
| Optical Size | 1/2" | 1/2" | 1/2" |
| Pixel Size | 9.9 µm x 9.9 µm | 8.3 µm x 8.3 µm | 4.65 µm x 4.65 µm |
| Max. Frame Rate (at full resolution) | 79 fps | 55 fps | 17 fps |
| Mono/Color | All models available in mono or color | | |
| Data Output Type | Fast Ethernet (100 Mbit/s) or Gigabit Ethernet (1000 Mbit/s) | | |
| Pixel Data Formats | Mono Models: | | |
| | Mono 8 ( = DCAM Mono 8)<br>Mono 16 ( = DCAM Mono 16)<br>Mono 12 Packed<br>YUV 4:2:2 Packed ( = DCAM YUV 4:2:2)<br>YUV 4:2:2 (YUYV) Packed | | |
| | Color Models: | | |
| | Mono 8 ( = DCAM Mono 8)<br>Bayer BG 8 ( = DCAM Raw 8)<br>Bayer BG 16 ( = DCAM Raw 16)<br>Bayer BG 12 Packed<br>YUV 4:2:2 Packed ( = DCAM YUV 4:2:2)<br>YUV 4:2:2 (YUYV) Packed | | |
| ADC Bit Depth | 12 bits | | |
| Synchronization | Via external trigger signal or via software | | |
| Exposure Control | Programmable via the camera API | | |
| Camera Power Requirements | +12 to +24 VDC, (min. +11.3 VDC, absolute max. +30.0 VDC), < 1% ripple | | |
| | 3.0 W @ 12 V | 3.0 W @ 12 V | 3.5 W @ 12 V |
| I/O Ports | 1 opto-isolated input port and 1 opto-isolated output port | | |
| Lens Adapter | C-mount | | |

| Specification | slA640-74gm/gc | slA780-54gm/gc | slA1390-17gm/gc |
|---|---|---|---|
| Size (L x W x H) | 73.7 mm x 44 mm x 29 mm (without lens adapter or connectors)<br>85.5 mm x 44 mm x 29 mm (with lens adapter and connectors) | | |
| Weight | 160 g (typical) | | |
| Conformity | CE, FCC, GenICam, GigE Vision, IP30 | | |

Table 1: General Specifications

| Specification | slA1400-17gm/gc |
|---|---|
| Sensor Size<br>(H x V pixels) | gm: 1392 x 1040<br>gc: 1390 x 1038 |
| Sensor Type | Sony ICX285 AL/AQ |
| | Progressive scan CCD |
| Optical Size | 2/3" |
| Pixel Size | 6.45 µm x 6.45 µm |
| Max. Frame Rate<br>(at full resolution) | 17 fps |
| Mono/Color | All models available in mono or color |
| Data Output Type | Fast Ethernet (100 Mbits/s) or Gigabit Ethernet (1000 Mbits/s) |
| Pixel Data Formats | Mono Models: |
| | Mono 8 ( = DCAM Mono 8)<br>Mono 16 ( = DCAM Mono 16)<br>Mono 12 Packed<br>YUV 4:2:2 Packed ( = DCAM YUV 4:2:2)<br>YUV 4:2:2 (YUYV) Packed |
| | Color Models: |
| | Mono 8 ( = DCAM Mono 8)<br>Bayer BG 8 ( = DCAM Raw 8)<br>Bayer BG 16 ( = DCAM Raw 16)<br>Bayer BG 12 Packed<br>YUV 4:2:2 Packed ( = DCAM YUV 4:2:2)<br>YUV 4:2:2 (YUYV) Packed |
| ADC Bit Depth | 12 bits |
| Synchronization | Via external trigger signal or via software |
| Exposure Control | Programmable via the camera API |
| Camera Power Requirements | +12 to +24 VDC, (min. +11.3 VDC, absolute max. +30.0 VDC), < 1% ripple |
| | 3.5 W @ 12 V |
| I/O Ports | 1 opto-isolated input port and 1 opto-isolated output port |
| Lens Adapter | C-mount |

| Specification | slA1400-17gm/gc |
|---|---|
| Size (L x W x H) | 73.7 mm x 44 mm x 29 mm (without lens adapter or connectors)<br>85.5 mm x 44 mm x 29 mm (with lens adapter and connectors) |
| Weight | 170 g (typical) |
| Conformity | CE, FCC, GenICam, GigE Vision, IP30 |

Table 2: General Specifications

# 1.3 Spectral Response for Mono Cameras

The following graphs show the spectral response for each available monochrome camera model.

| | |
|---|---|
| | The spectral response curves excludes lens characteristics and light source characteristics. |

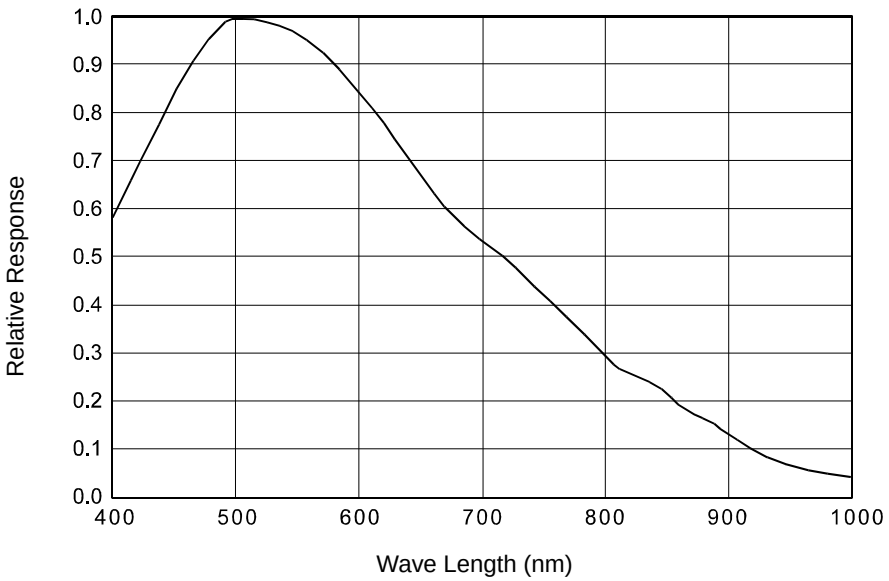


Fig. 1: slA640-74gm Spectral Response

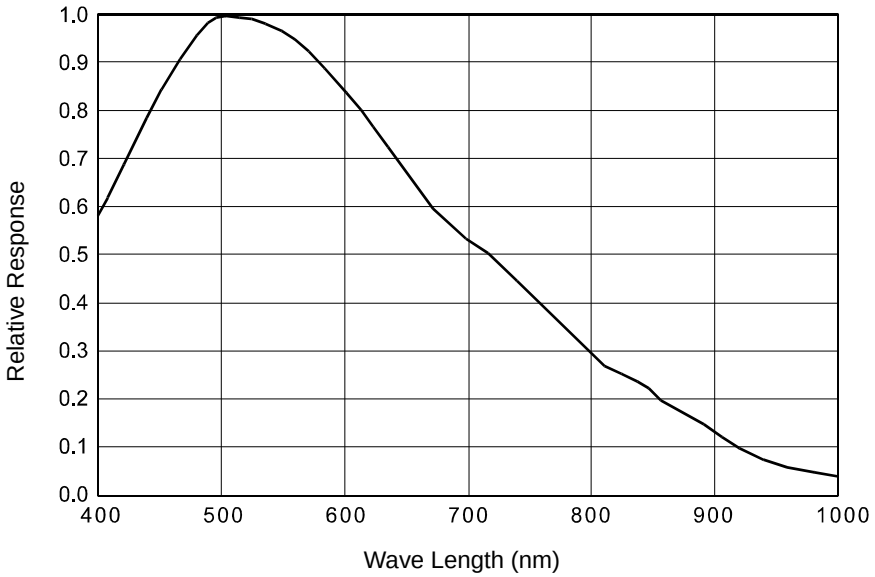


Fig. 2: slA780-54gm Spectral Response

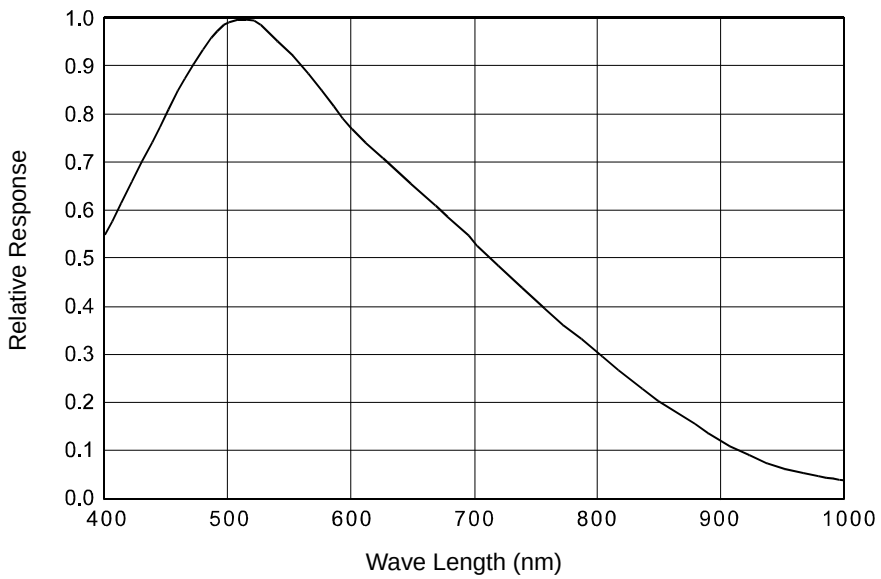


Fig. 3: slA1390-17gm Spectral Response

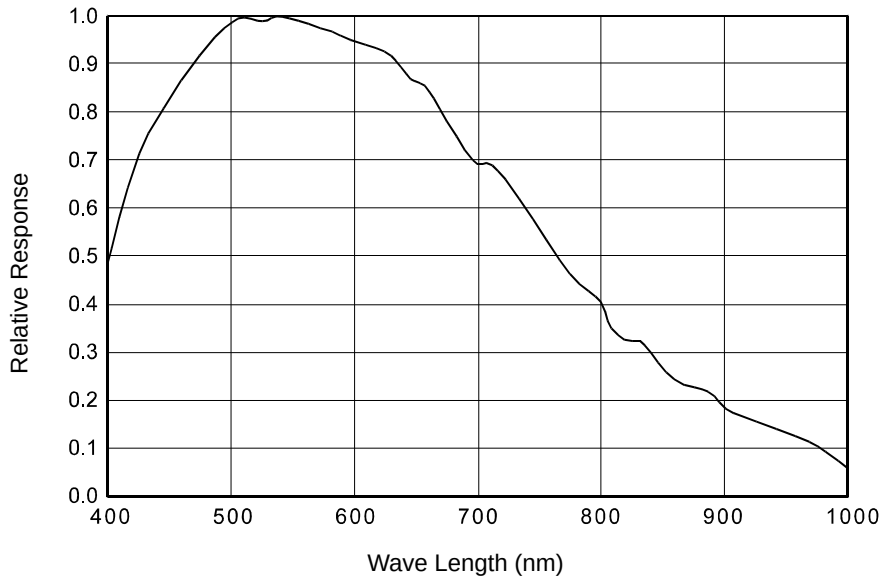


Fig. 4: slA1400-17gm Spectral Response

# 1.4 Spectral Response for Color Cameras

The following graphs show the spectral response for each available color camera model

| | |
|---|---|
| ⓘ | The spectral response curves exclude lens characteristics, light source characteristics, and IR cut filter characteristics.<br>To obtain best performance from color models of the camera, use of a dielectric IR cut filter is recommended. The filter should transmit in a range from 400 nm to 700 ... 720 nm, and it should cut off from 700 ... 720 nm to 1100 nm.<br>A suitable IR cut filter is included in the C-mount lens adapter on color models of the camera. |

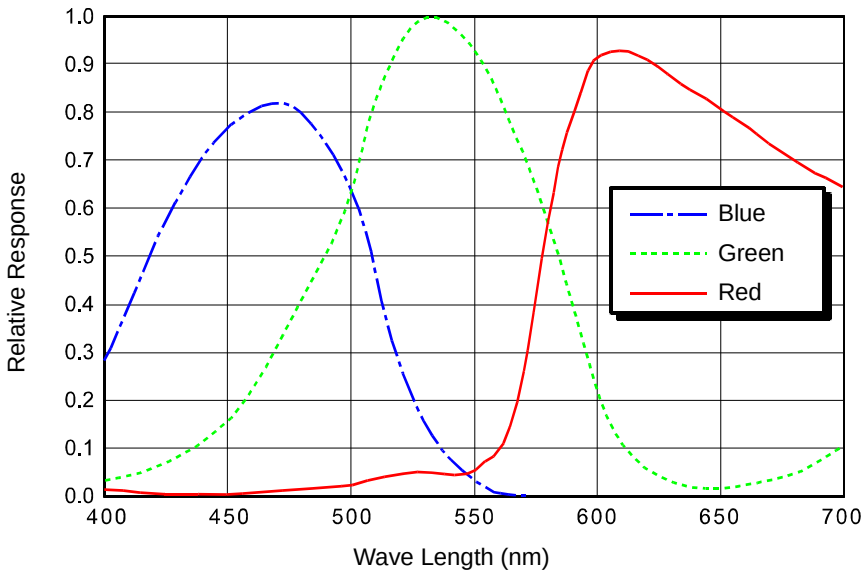


Fig. 5: slA640-74gc Spectral Response

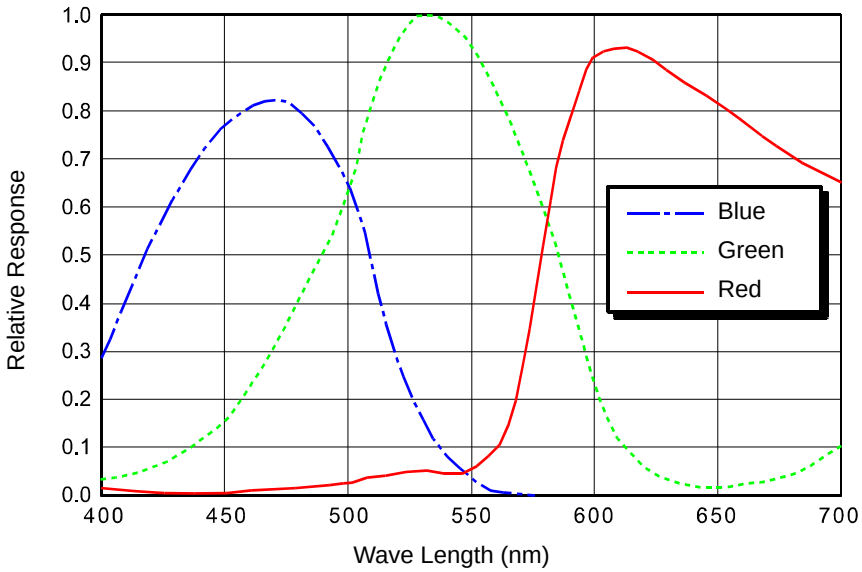


Fig. 6: slA780-54gc Spectral Response

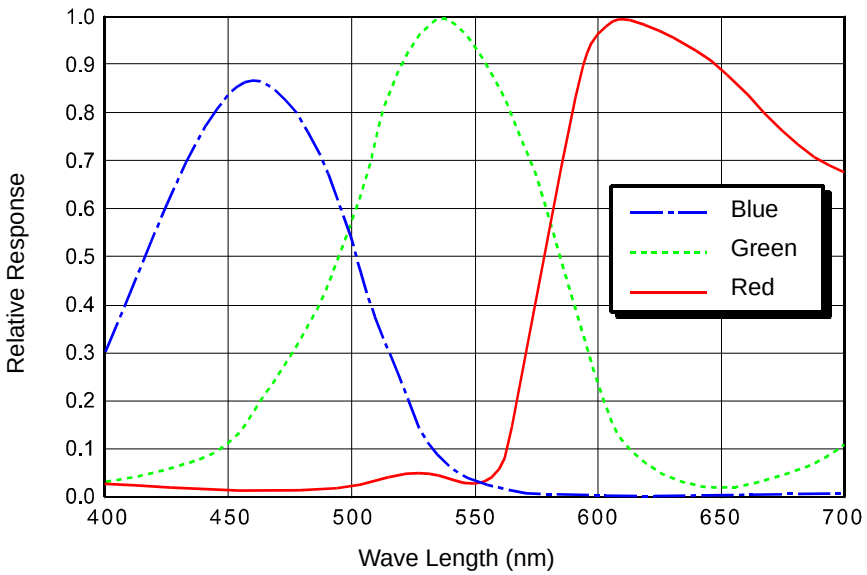


Fig. 7: slA1390-17gc Spectral Response

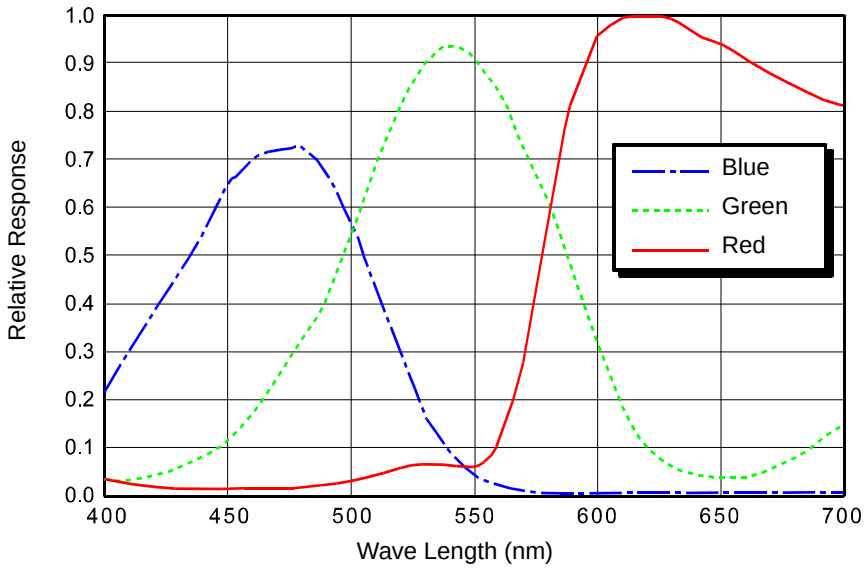


Fig. 8: slA1400-17gc Spectral Response

# 1.5 Mechanical Specifications

The camera housing conforms to protection class IP30 assuming that the lens mount is covered by a lens or by the cap that is shipped with the camera.

## 1.5.1 Camera Dimensions and Mounting Points

The cameras are manufactured with high precision. Planar, parallel, and angular sides guarantee precise mounting with high repeatability.

The dimensions in millimeters for the cameras are as shown in Figure 9.

Camera housings are equipped with four mounting holes on the top and four mounting holes on the bottom as shown in the drawings.

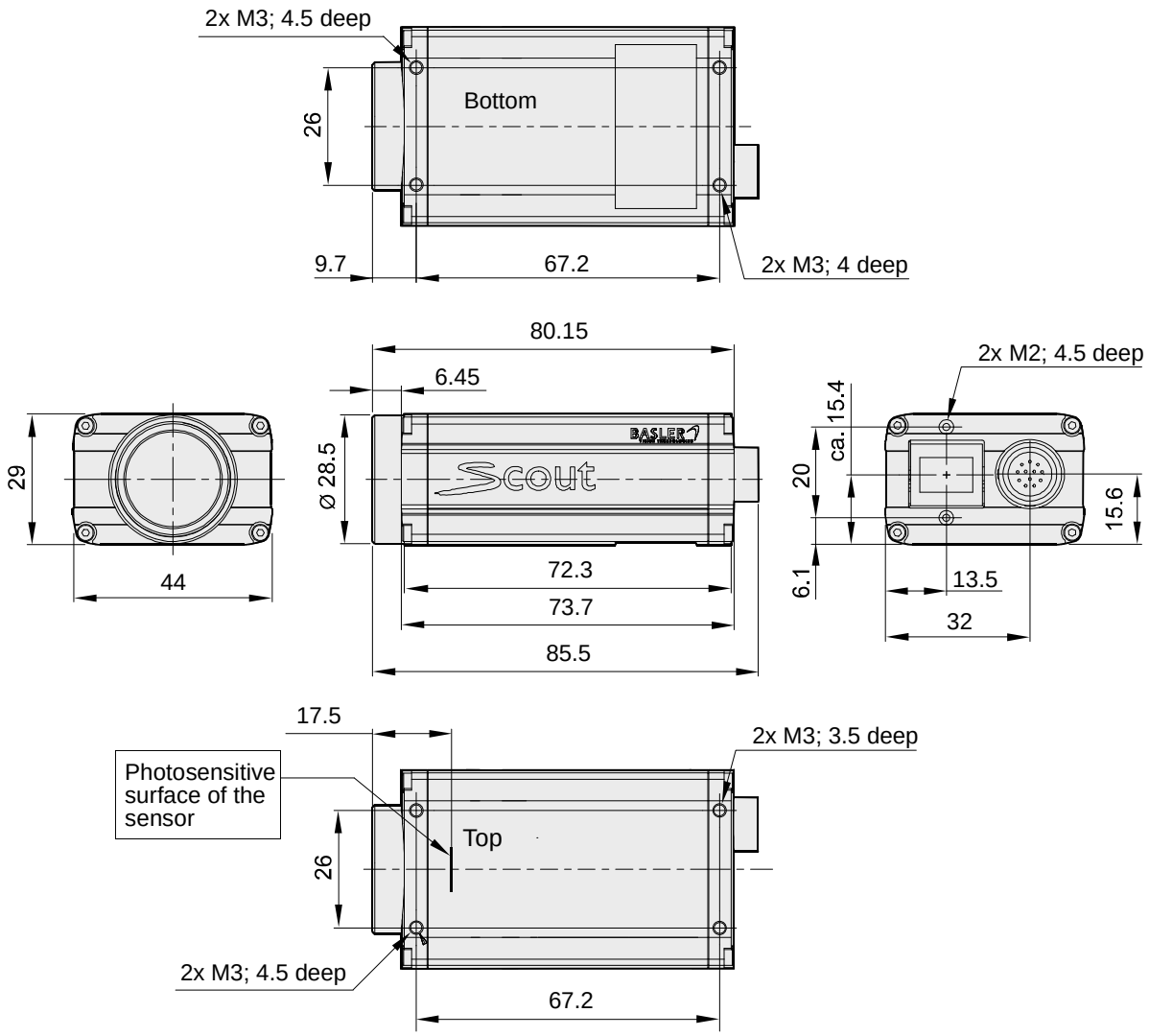


Fig. 9: Mechanical Dimensions (in mm) for the Cameras

## 1.5.2 Maximum Thread Length on Color Cameras

The C-mount lens adapter on color models of the camera is equipped with an internal IR cut filter. As shown below, the length of the threads on any lens you use with a color camera must be less than 8.0 mm. If a lens with a longer thread length is used, the IR cut filter will be damaged or destroyed and the camera will no longer operate.

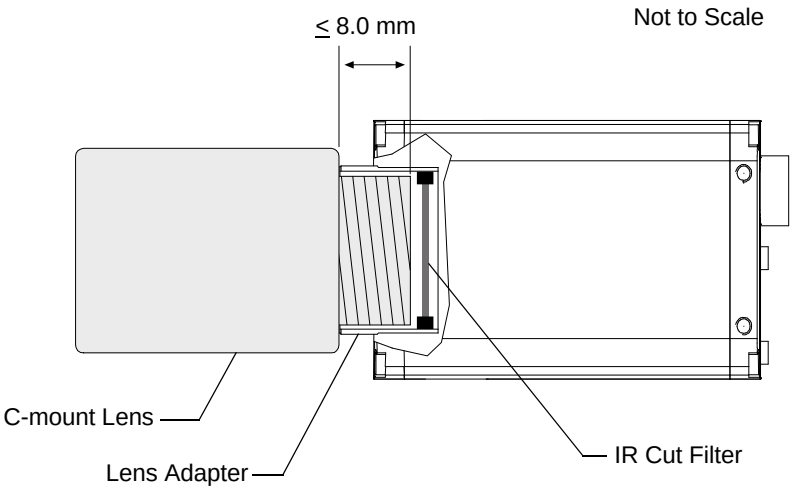


Fig. 10: Maximum Lens Thread Length on Color Cameras

## 1.5.3 Mechanical Stress Test Results

Scout cameras were submitted to an independent mechanical testing laboratory and subjected to the stress tests listed below. The mechanical stress tests were performed on selected camera models. After mechanical testing, the cameras exhibited no detectable physical damage and produced normal images during standard operational testing.

| Test | Standard | Conditions |
|---|---|---|
| Vibration (sinusoidal, each axis) | DIN EN 60068-2-6 | 10-58 Hz / 1.5 mm_58-500 Hz / 20 g_1 Octave/Minute<br>10 repetitions |
| Shock (each axis) | DIN EN 60068-2-27 | 20 g / 11 ms / 10 shocks positive<br>20 g / 11 ms / 10 shocks negative |
| Bump (each axis) | DIN EN 60068-2-29 | 20 g / 11 ms / 100 shocks positive<br>20 g / 11 ms / 100 shocks negative |
| Vibration (broad-band random, digital control, each axis) | DIN EN 60068-2-64 | 15-500 Hz / 0.05 PSD (ESS standard profile) / 00:30 h |

Table 3: Mechanical Stress Tests

The mechanical stress tests were performed with a dummy lens connected. The dummy lens was 35 mm long and had a mass of 66 g. Using a heavier or longer lens requires an additional support for the lens.

# 1.6 Software Licensing Information

The software in the camera includes the LWIP TCP/IP implementation. The copyright information for this implementation is as follows:

Copyright (c) 2001, 2002 Swedish Institute of Computer Science. All rights reserved.

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# 1.7 Avoiding EMI and ESD Problems

The cameras are frequently installed in industrial environments. These environments often include devices that generate electromagnetic interference (EMI) and they are prone to electrostatic discharge (ESD). Excessive EMI and ESD can cause problems with your camera such as false triggering or can cause the camera to suddenly stop capturing images. EMI and ESD can also have a negative impact on the quality of the image data transmitted by the camera.

To avoid problems with EMI and ESD, you should follow these general guidelines:

- Always use high quality shielded cables. The use of high quality cables is one of the best defenses against EMI and ESD.
- Try to use camera cables that are the correct length and try to run the camera cables and power cables parallel to each other. Avoid coiling camera cables. If the cables are too long, use a meandering path rather then coiling the cables.
- Avoid placing camera cables parallel to wires carrying high-current, switching voltages such as wires supplying stepper motors or electrical devices that employ switching technology. **Placing camera cables near to these types of devices may cause problems with the camera.**
- Attempt to connect all grounds to a single point, e.g., use a single power outlet for the entire system and connect all grounds to the single outlet. This will help to avoid large ground loops. (Large ground loops can be a primary cause of EMI problems.)
- Use a line filter on the main power supply.
- Install the camera and camera cables as far as possible from devices generating sparks. If necessary, use additional shielding.
- Decrease the risk of electrostatic discharge by taking the following measures:
  - Use conductive materials at the point of installation (e.g., floor, workplace).
  - Use suitable clothing (cotton) and shoes.
  - Control the humidity in your environment. Low humidity can cause ESD problems.

| | |
|---|---|
| | The Basler application note called *Avoiding EMI and ESD in Basler Camera Installations* provides much more detail about avoiding EMI and ESD.<br>This application note can be obtained from the Downloads section of our website:<br>www.baslerweb.com |

# 1.8 Environmental Requirements

## 1.8.1 Temperature and Humidity

| | |
|---|---|
| Housing temperature during operation: | 0 °C ... +50 °C (+32 °F ... +122 °F) |
| Humidity during operation: | 20 % ... 80 %, relative, non-condensing |
| Storage temperature: | -20 °C ... +80 °C (-4 °F ... +176 °F) |
| Storage humidity: | 20 % ... 80 %, relative, non-condensing |

## 1.8.2 Ventilation

Allow sufficient air circulation around the camera to prevent internal heat build-up in your system and to keep the camera’s housing temperature below 50 °C. Additional cooling devices such as fans or heat sinks are not normally required, but should be provided if necessary.

# 1.9 Precautions

**NOTICE**

Avoid Dust on the Sensor.

The camera is shipped with a cap on the lens mount. To avoid collecting dust on the camera's IR cut filter (color cameras) or sensor (mono cameras), make sure that you always put the cap in place when there is no lens mounted on the camera.

To further enhance dust protection, the internal space in the camera that contains the imaging sensor is sealed off from the camera's other internal spaces.

**NOTICE**

Lens Thread Length is Limited.

Color models of the camera are equipped with an IR cut filter mounted inside of the C-mount adapter. The location of this filter limits the length of the threads on any lens you use with the camera. If a lens with a very long thread length is used, the IR cut filter will be damaged or destroyed and the camera will no longer operate.

For more specific information about the lens thread length, see Section 1.5.2 on page 14.

**NOTICE**

Voltage Outside of Specified Range Can Cause Damage.

If the voltage of the power to the camera is greater than +30.0 VDC damage to the camera can result. If the voltage is less than +11.3 VDC, the camera may operate erratically.

**NOTICE**

An Incorrect Plug Can Damage the 12-pin Connector.

The plug on the cable that you attach to the camera's 12-pin connector must have 12 pins. Use of a smaller plug, such as one with 10 pins or 8 pins, can damage the pins in the camera's 12-pin connector.

***NOTICE***

Inappropriate Code May Cause Unexpected Camera Behavior.

The code snippets provided in this manual are included as sample code only. Inappropriate code may cause your camera to function differently than expected and may compromise your application. To ensure that the snippets will work properly in your application, you must adjust them to meet your specific needs and must test them thoroughly prior to use.

The code snippets in this manual are written in C++. Other programming languages can also be used to write code for use with Basler pylon.
When writing code, you should use a programming language that is both compatible with pylon and appropriate for your application.

For more information about the programming languages that can be used with Basler pylon, see the documentation included with the pylon package.

## Warranty Precautions

**To ensure that your warranty remains in force:**

### Do not remove the camera's serial number label

If the label is removed and the serial number can't be read from the camera's registers, the warranty is void.

### Do not open the camera housing

Do not open the housing. Touching internal components may damage them.

### Keep foreign matter outside of the camera

Be careful not to allow liquid, flammable, or metallic material inside of the camera housing. If operated with any foreign matter inside, the camera may fail or cause a fire.

### Avoid Electromagnetic fields

Do not operate the camera in the vicinity of strong electromagnetic fields. Avoid electrostatic charging.

### Transport Properly

Transport the camera in its original packaging only. Do not discard the packaging.

### Clean Properly

Avoid cleaning the surface of the camera's sensor if possible. If you must clean it, use a soft, lint free cloth dampened with a small quantity of high quality window cleaner. Because electrostatic discharge can damage the sensor, you must use a cloth that will not generate static during cleaning (cotton is a good choice).

To clean the surface of the camera housing, use a soft, dry cloth. To remove severe stains, use a soft cloth dampened with a small quantity of neutral detergent, then wipe dry.

Do not use solvents or thinners to clean the housing; they can damage the surface finish.

### Read the manual

Read the manual carefully before using the camera!

# 2 Installation

The information you will need to install and operate the camera is included in the Installation and Setup Guide for Cameras Used with Basler’s pylon API (AW000611xx000).

You can download the Installation and Setup Guide for Cameras Used with Basler’s pylon API from the Basler website: www.baslerweb.com

The guide includes the information you will need to install both hardware and software and to begin capturing images. It also describes the recommended network adapters, describes the recommended architecture for the network to which your camera is attached, and deals with the IP configuration of your camera and network adapter.

After completing your camera installation, refer to the "Basler Network Drivers and Parameters" and "Network Related Camera Parameters and Managing Bandwidth" sections of this camera User’s Manual for information about improving your camera’s performance in a network and about using multiple cameras.

# 3 Tools for Changing Camera Parameters

This chapter explains the options available for changing the camera's parameters. The available options let you change parameters either by using stand-alone tools that access the camera via a GUI or by accessing the camera from within your software application.

## 3.1 The pylon Viewer

The Basler pylon Viewer is a standalone application that lets you view and change most of the camera's parameter settings via a GUI based interface. The viewer also lets you acquire images, display them, and save them. Using the pylon Viewer software is a very convenient way to get your camera up and running quickly when you are doing your initial camera evaluation or doing a camera design-in for a new project.

The pylon Viewer is included in Basler's pylon Driver Package. You can obtain the pylon package from the Downloads section of our website: www.baslerweb.com

For more information about using the viewer, see the Installation and Setup Guide for Cameras Used with Basler's pylon API (AW000611xx000). You can download the guide from the Basler website: www.baslerweb.com.

## 3.2 The IP Configuration Tool

The Basler IP Configuration Tool is a standalone application that lets you change the IP configuration of the camera via a GUI. The tool will detect all Basler GigE cameras attached to your network and let you make changes to a selected camera.

The IP Configuration Tool is included in Basler's pylon Driver Package. You can obtain the pylon package from the Downloads section of our website: www.baslerweb.com

For more information about using the IP Configuration Tool, see the Installation and Setup Guide for Cameras Used with Basler's pylon API (AW000611xx000). You can download the guide from the Basler website: www.baslerweb.com.

# 3.3 The pylon API

You can access all of the camera's parameters and can control the camera's full functionality from within your application software by using Basler's pylon API. The Basler pylon Programmer's Guide and API Reference contains an introduction to the API and includes information about all of the methods and objects included in the API. The programmer's guide and API reference are included in the pylon SDK.

The Basler pylon Software Development Kit (SDK) includes a set of sample programs that illustrate how to use the pylon API to parameterize and operate the camera. These samples include Microsoft® Visual Studio® solution and project files demonstrating how to set up the build environment to build applications based on the API.

The SDK is available in the Downloads section of the Basler website: www.baslerweb.com

For more information about installing pylon software, see the installation and Setup Guide for Cameras Used with Basler's pylon API (AW000611xx000). You can download the guide from the Basler website: www.baslerweb.com.

# 4 Basler Network Drivers and Parameters

This section describes the Basler network drivers available for your camera and provides detailed information about the parameters associated with the drivers.

Two network drivers are available for the network adapter used with your GigE cameras:

- The **Basler filter driver** is a basic GigE Vision network driver that is compatible with all network adapters. The advantage of this driver is its extensive compatibility.
- The **Basler performance driver** is a hardware specific GigE Vision network driver. The driver is only compatible with network adapters that use specific Intel chipsets. The advantage of the performance driver is that it significantly lowers the CPU load needed to service the network traffic between the PC and the camera(s). It also has a more robust packet resend mechanism.

During the installation process you should have installed either the filter driver or the performance driver.

For more information about compatible Intel chipsets, see the Installation and Setup Guide for Cameras Used with Basler's pylon API (AW000611xx000).

For more information about installing the network drivers, see the Installation and Setup Guide for Cameras Used with Basler's pylon API (AW000611xx000).

# 4.1 The Basler Filter Driver

The Basler filter driver is a basic driver GigE Vision network driver. It is designed to be compatible with most network adapter cards.

The functionality of the filter driver is relatively simple. For each frame, the driver checks the order of the incoming packets. If the driver detects that a packet or a group of packets is missing, it will wait for a specified period of time to see if the missing packet or group of packets arrives. If the packet or group does not arrive within the specified period, the driver will send a resend request for the missing packet or group of packets.

The parameters associated with the filter driver are described below.

**Enable Resend** - Enables or disables the packet resend mechanism.

If packet resend is disabled and the filter driver detects that a packet has been lost during transmission, the grab result for the returned buffer holding the image will indicate that the grab failed and the image will be incomplete.

If packet resend is enabled and the driver detects that a packet has been lost during transmission, the driver will send a resend request to the camera. If the camera still has the packet in its buffer, it will resend the packet. If there are several lost packets in a row, the resend requests will be combined.

**Packet Timeout** - The Packet Timeout parameter defines how long (in milliseconds) the filter driver will wait for the next expected packet before it initiates a resend request. Ensure the Packet Timeout parameter is set to a longer time interval than the time interval set for the inter-packet delay.

**Frame Retention** - The Frame Retention parameter sets the timeout (in milliseconds) for the frame retention timer. Whenever the filter driver detects the leader for a frame, the frame retention timer starts. The timer resets after each packet in the frame is received and will timeout after the last packet is received. If the timer times out at any time before the last packet is received, the buffer for the frame will be released and will be indicated as an unsuccessful grab.

You can set the filer driver parameter values from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to read and write the parameter values:

```
// Enable Resend
Camera_t::StreamGrabber_t StreamGrabber ( Camera.GetStreamGrabber(0) );
StreamGrabber.EnableResend.SetValue(false); // disable resends

// Packet Timeout/FrameRetention
Camera_t::StreamGrabber_t StreamGrabber ( Camera.GetStreamGrabber(0) );
StreamGrabber.PacketTimeout.SetValue( 40 );
StreamGrabber.FrameRetention.SetValue( 200 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see the Installation and Setup Guide for Cameras Used with Basler’s pylon API (AW000611xx000).

# 4.2 The Basler Performance Driver

The Basler performance driver is a hardware specific GigE Vision network driver compatible with network adapters that use specific Intel chipsets. The main advantage of the performance driver is that it significantly lowers the CPU load needed to service the network traffic between the PC and the camera(s). It also has a more robust packet resend mechanism.

For more information about compatible Intel chipsets, see the Installation and Setup Guide for Cameras Used with Basler's pylon API (AW000611xx000).

The performance driver uses two distinct "resend mechanisms" to trigger resend requests for missing packets:

- The threshold resend mechanism
- The timeout resend mechanism

The mechanisms are independent from each other and can be used separately. However, for maximum efficiency and for ensuring that resend requests will be sent for all missing packets, we recommend using both resend mechanisms in a specific, optimized combination, as provided by the parameter default values.

The performance driver's parameter values determine how the resend mechanisms act and how they relate to each other. You can set the parameter values by using the pylon Viewer or from within your application software by using the pylon API.

The parameter default values will provide for the following:

- The threshold resend mechanism precedes the timeout resend mechanism. This ensures that a resend request is sent for every missing packet, even at very high rates of arriving packets.
- The timeout resend mechanism will be effective for those missing packets that were not resent after the first resend request.

**We strongly recommend using the default parameter settings.** Only users with the necessary expertise should change the default parameter values.

The Basler performance driver uses a "receive window" to check the status of packets. The check for missing packets is made as packets enter the receive window. If a packet arrives from higher in the sequence of packets than expected, the preceding skipped packet or packets are detected as missing. For example, suppose packet (n-1) has entered the receive window and is immediately followed by packet (n+1). In this case, as soon as packet (n+1) enters the receive window, packet n will be detected as missing.

## General Parameters

**Enable Resend** - Enables the packet resend mechanisms.

If the Enable Resend parameter is set to false, the resend mechanisms are disabled. The performance driver will not check for missing packets and will not send resend requests to the camera.

If the Enable Resend parameter is set to true, the resend mechanisms are enabled. The performance driver will check for missing packets. Depending on the parameter settings and the resend response, the driver will send one or several resend requests to the camera.

**Receive Window Size** - Sets the size of the receive window.

## Threshold Resend Mechanism Parameters

The threshold resend request mechanism is illustrated in Figure 11 where the following assumptions are made:

- Packets 997, 998, and 999 are missing from the stream of packets.
- Packet 1002 is missing from the stream of packets.

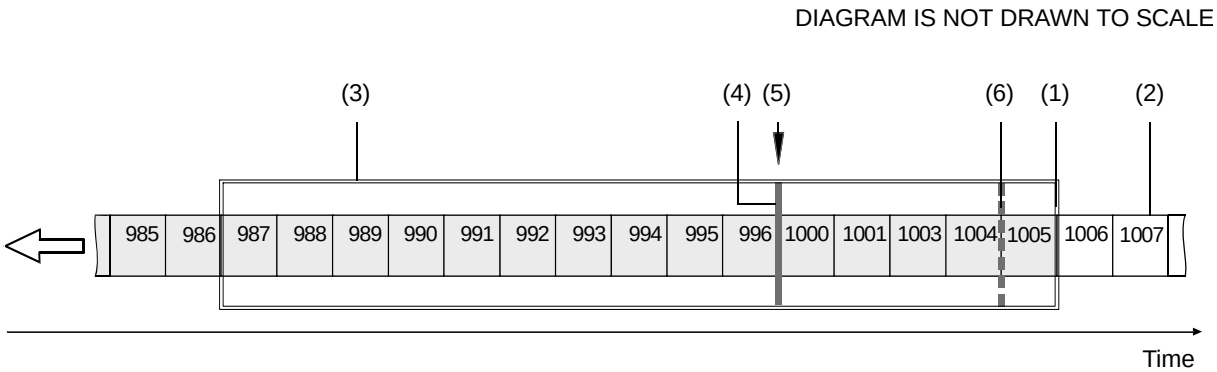



Fig. 11: Example of a Receive Window with Resend Request Threshold & Resend Request Batching Threshold

(1) Front end of the receive window. Missing packets are detected here.

(2) Stream of packets. Gray indicates that the status was checked as the packet entered the receive window. White indicates that the status has not yet been checked.

(3) Receive window of the performance driver.

(4) Threshold for sending resend requests (resend request threshold).

(5) A separate resend request is sent for each packets 997, 998, and 999.

(6) Threshold for batching resend requests for consecutive missing packets (resend request batching threshold). Only one resend request will be sent for the consecutive missing packets.

**Resend Request Threshold** - This parameter determines the location of the resend request threshold within the receive window as shown in Figure 11. The parameter value is in per cent of the width of the receive window. In Figure 11 the resend request threshold is set at 33.33% of the width of the receive window.

A stream of packets advances packet by packet beyond the resend request threshold (i.e. to the left of the resend request threshold in Figure 11). As soon as the position where a packet is missing advances beyond the resend request threshold, a resend request is sent for the missing packet.

In the example shown in Figure 11, packets 987 to 1005 are within the receive window and packets 997 to 999 and 1002 were detected as missing. In the situation shown, a resend request is sent to the camera for each of the missing consecutive packets 997 to 999. The resend requests are sent after packet 996 - the last packet of the intact sequence of packets - has advanced beyond the resend request threshold and before packet 1000 - the next packet in the stream of packets - can advance beyond the resend request threshold. Similarly, a resend request will be sent for missing packet 1002 after packet 1001 has advanced beyond the resend request threshold and before packet 1003 can advance beyond the resend request threshold.

**Resend Request Batching** - This parameter determines the location of the resend request batching threshold in the receive window (Figure 11). The parameter value is in per cent of a span that starts with the resend request threshold and ends with the front end of the receive window. The maximum allowed parameter value is 100. In Figure 11 the resend request batching threshold is set at 80% of the span.

The resend request batching threshold relates to consecutive missing packets, i.e., to a continuous sequence of missing packets. Resend request batching allows grouping of consecutive missing packets for a single resend request rather than sending a sequence of resend requests where each resend request relates to just one missing packet.

The location of the resend request batching threshold determines the maximum number of consecutive missing packets that can be grouped together for a single resend request. The maximum number corresponds to the number of packets that fit into the span between the resend request threshold and the resend request batching threshold plus one.

If the Resend Request Batching parameter is set to 0, no batching will occur and a resend request will be sent for each single missing packet. For other settings, consider an example: Suppose the Resend Request Batching parameter is set to 80 referring to a span between the resend request threshold and the front end of the receive window that can hold five packets (Figure 11). In this case 4 packets (5 x 80%) will fit into the span between the resend request threshold and the resend request batching threshold. Accordingly, the maximum number of consecutive missing packets that can be batched is 5 (4 + 1).

## Timeout Resend Mechanism Parameters

The timeout resend mechanism is illustrated in Figure 12 where the following assumptions are made:

- The frame includes 3000 packets.
- Packet 1002 is missing within the stream of packets and has not been recovered.
- Packets 2999 and 3000 are missing at the end of the stream of packets (end of the frame).
- The Maximum Number Resend Requests parameter is set to 3.

DIAGRAM IS NOT DRAWN TO SCALE

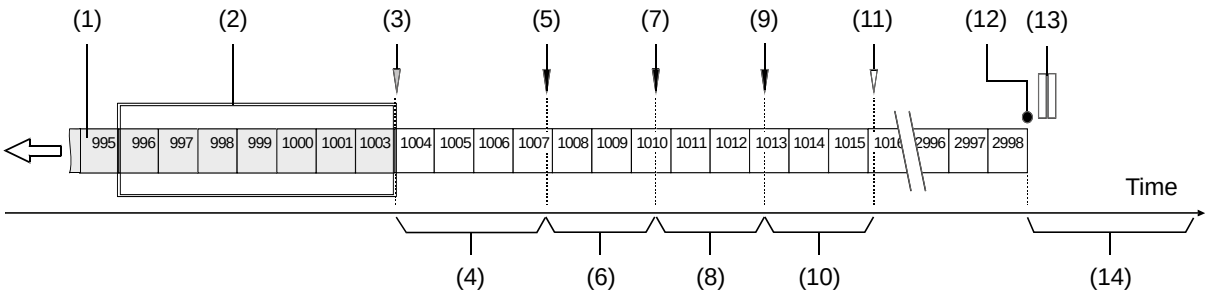



Fig. 12: Incomplete Stream of Packets and Part of the Resend Mechanism

(1) Stream of packets. Gray indicates that the status was checked as the packet entered the receive window. White indicates that the status has not yet been checked.

(2) Receive window of the performance driver.

(3) As packet 1003 enters the receive window, packet 1002 is detected as missing.

(4) Interval defined by the Resend Timeout parameter.

(5) The Resend Timeout interval expires and the first resend request for packet 1002 is sent to the camera. The camera does not respond with a resend.

(6) Interval defined by the Resend Response Timeout parameter.

(7) The Resend Response Timeout interval expires and a second resend request for packet 1002 is sent to the camera. The camera does not respond with a resend.

(8) Interval defined by the Resend Response Timeout parameter.

(9) The Resend Response Timeout interval expires and a third resend request for packet 1002 is sent to the camera. The camera still does not respond with a resend.

(10) Interval defined by the Resend Response Timeout parameter.

(11) Because the maximum number of resend requests has been sent and the last Resend Response Timeout interval has expired, packet 1002 is now considered as lost.

(12) End of the frame.

(13) Missing packets at the end of the frame (2999 and 3000).

(14) Interval defined by the Packet Timeout parameter.

**Maximum Number Resend Requests** - The Maximum Number Resend Requests parameter sets the maximum number of resend requests the performance driver will send to the camera for each missing packet.

**Resend Timeout** - The Resend Timeout parameter defines how long (in milliseconds) the performance driver will wait after detecting that a packet is missing before sending a resend request to the camera. The parameter applies only once to each missing packet after the packet was detected as missing.

**Resend Request Response Timeout** - The Resend Request Response Timeout parameter defines how long (in milliseconds) the performance driver will wait after sending a resend request to the camera before considering the resend request as lost.

If a resend request for a missing packet is considered lost and if the maximum number of resend requests as set by the Maximum Number Resend Requests parameter has not yet been reached, another resend request will be sent. In this case, the parameter defines the time separation between consecutive resend requests for a missing packet.

**Packet Timeout** - The Packet Timeout parameter defines how long (in milliseconds) the performance driver will wait for the next expected packet before it sends a resend request to the camera. This parameter ensures that resend requests are sent for missing packets near to the end of a frame. In the event of a major interruption in the stream of packets, the parameter will also ensure that resend requests are sent for missing packets that were detected to be missing immediately before the interruption. Make sure the Packet Timeout parameter is set to a longer time interval than the time interval set for the inter-packet delay.

## Threshold and Timeout Resend Mechanisms Combined

Figure 13 illustrates the combined action of the threshold and the timeout resend mechanisms where the following assumptions are made:

- All parameters set to default.
- The frame includes 3000 packets.
- Packet 1002 is missing within the stream of packets and has not been recovered.
- Packets 2999 and 3000 are missing at the end of the stream of packets (end of the frame).

The default values for the performance driver parameters will cause the threshold resend mechanism to become operative before the timeout resend mechanism. This ensures maximum efficiency and that resend requests will be sent for all missing packets.

With the default parameter values, the resend request threshold is located very close to the front end of the receive window. Accordingly, there will be only a minimum delay between detecting a missing packet and sending a resend request for it. In this case, a delay according to the Resend Timeout parameter will not occur (see Figure 13). In addition, resend request batching will not occur.

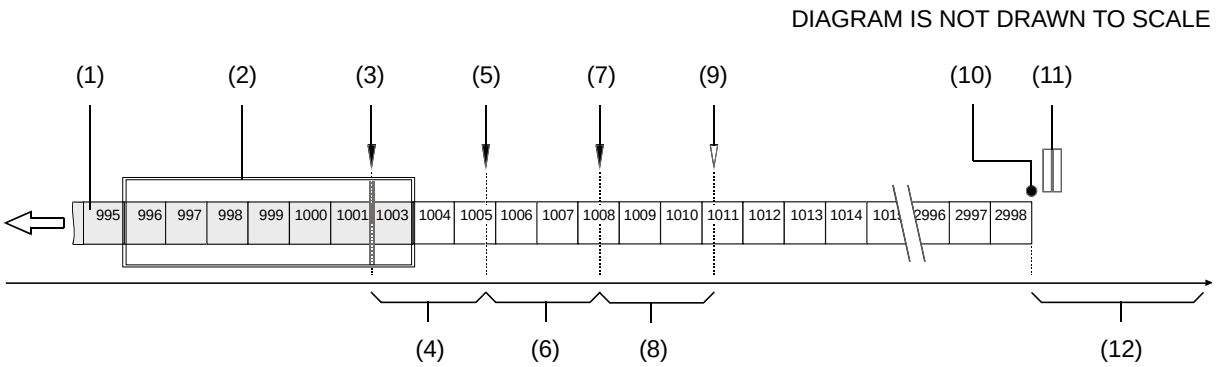



Fig. 13: Combination of Threshold Resend Mechanism and Timeout Resend Mechanism

(1) Stream of packets, Gray indicates that the status was checked as the packet entered the receive window. White indicates that the status has not yet been checked.

(2) Receive window of the performance driver.

(3) Threshold for sending resend requests (resend request threshold). The first resend request for packet 1002 is sent to the camera. The camera does not respond with a resend.

(4) Interval defined by the Resend Response Timeout parameter.

(5) The Resend Timeout interval expires and the second resend request for packet 1002 is sent to the camera. The camera does not respond with a resend.

(6) Interval defined by the Resend Response Timeout parameter

(7) The Resend Timeout interval expires and the third resend request for packet 1002 is sent to the camera. The camera does not respond with a resend.

(8) Interval defined by the Resend Response Timeout parameter

(9) Because the maximum number of resend requests has been sent and the last Resend Response Timeout interval has expired, packet 1002 is now considered as lost.

(10) End of the frame.

(11) Missing packets at the end of the frame (2999 and 3000).

(12) Interval defined by the Packet Timeout parameter.

You can set the performance driver parameter values from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to read and write the parameter values:

```
// Get the Stream Parameters object
Camera_t::StreamGrabber_t StreamGrabber( Camera.GetStreamGrabber(0) );

// Write the ReceiveWindowSize parameter
StreamGrabber.ReceiveWindowSize.SetValue( 16 );

// Disable packet resends
StreamGrabber.EnableResend.SetValue( false );

// Write the PacketTimeout parameter
StreamGrabber.PacketTimeout.SetValue( 40 );

// Write the ResendRequestThreshold parameter
StreamGrabber.ResendRequestThreshold.SetValue( 5 );

// Write the ResendRequestBatching parameter
StreamGrabber.ResendRequestBatching.SetValue( 10 );

// Write the ResendTimeout parameter
StreamGrabber.ResendTimeout.SetValue( 2 );

// Write the ResendRequestResponseTimeout parameter
StreamGrabber.ResendRequestResponseTimeout.SetValue( 2 );

// Write the MaximumNumberResendRequests parameter
StreamGrabber.MaximumNumberResendRequests.SetValue( 25 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters. (Note that the performance driver parameters will only appear in the viewer if the performance driver is installed on the adapter to which your camera is connected.)

For more information about the pylon Viewer, see the Installation and Setup Guide for Cameras Used with Basler’s pylon API (AW000611xx000).

## Adapter Properties

When the Basler Performance driver is installed, it adds a set of "advanced" properties to the network adapter. These properties include:

**Max Packet Latency** - A value in microseconds that defines how long the adapter will wait after it receives a packet before it generates a packet received interrupt.

**Max Receive Inter-packet Delay** - A value in microseconds that defines the maximum amount of time allowed between incoming packets.

**Maximum Interrupts per Second** - Sets the maximum number of interrupts per second that the adapter will generate.

**Network Address** - allows the user to specify a MAC address that will override the default address provided by the adapter.

**Packet Buffer Size** - Sets the size in bytes of the buffers used by the receive descriptors and the transmit descriptors.

**Receive Descriptors** - Sets the number of descriptors to use in the adapter's receiving ring.

**Transmit Descriptors** - Sets the number of descriptors to use in the adapter's transmit ring.

To access the advanced properties for an adapter:

1. Open a **Network Connections** window and find the connection for your network adapter.
2. Right click on the name of the connection and select **Properties** from the drop down menu.
3. A **LAN Connection Properties** window will open. Click the **Configure** button.
4. An **Adapter Properties** window will open. Click the **Advanced** tab.

**We strongly recommend using the default parameter settings.** Changing the parameters can have a significant negative effect on the performance of the adapter and the driver.

# 4.3 Transport Layer Parameters

The transport layer parameters are part of the camera's basic GigE implementation. These parameters do not normally require adjustment.

**Read Timeout** - If a register read request is sent to the camera via the transport layer, this parameter designates the time out (in milliseconds) within which a response must be received.

**Write Timeout** - If a register write request is sent to the camera via the transport layer, this parameter designates the time out (in milliseconds) within which an acknowledge must be received.

**Heartbeat Timeout** - The GigE Vision standard requires implementation of a heartbeat routine to monitor the connection between the camera and the host PC. This parameter sets the heartbeat timeout (in milliseconds). If a timeout occurs, the camera releases the network connection and enters a state that allows reconnection.

Management of the heartbeat time is normally handled by the Basler's basic GigE implementation and changing this parameter is not required for normal camera operation. However, if you are debugging an application and you stop at a breakpoint, you will have a problem with the heartbeat timer. The timer will time out when you stop at a breakpoint and the connection to the camera will be lost. When debugging, you should increase the heartbeat timeout to a high value to avoid heartbeat timeouts at breakpoints. When debugging is complete, you should return the timeout to its normal setting.

You can set the driver related transport layer parameter values from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to read and write the parameter values:

```
 // Read/Write Timeout
Camera_t::TlParams_t TlParams( Camera.GetTLNodeMap() );
TlParams.ReadTimeout.SetValue(500);  // 500 milliseconds
TlParams.WriteTimeout.SetValue(500); // 500 milliseconds

// Heartbeat Timeout
Camera_t::TlParams_t TlParams( Camera.GetTLNodeMap() );
TlParams.HeartbeatTimeout.SetValue(5000);  // 5 seconds
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

# 5 Network Related Camera Parameters and Managing Bandwidth

This section describes the camera parameters that are related to the camera's performance on the network. It also describes how to use the parameters to manage the available network bandwidth when you are using multiple cameras.

## 5.1 Network Related Parameters in the Camera

The camera includes several parameters that determine how it will use its network connection to transmit data to the host PC. The list below describes each parameter and provides basic information about how the parameter is used. The following section describes how you can use the parameters to manage the bandwidth used by each camera on your network.

**Payload Size** (read only)

Indicates the total size in bytes of the image data plus any chunk data (if chunks are enabled) that the camera will transmit. Packet headers are not included.

**Stream Channel Selector** (read/write)

The GigE Vision standard specifies a mechanism for establishing several separate stream channels between the camera and the PC. This parameter selects the stream channel that will be affected when the other network related parameters are changed.

Currently, the cameras support only one stream channel, i.e., stream channel 0.

**Packet Size** (read/write)

As specified in the GigE Vision standard, each acquired image will be fit into a data block. The block contains three elements: a *data leader* consisting of one packet used to signal the beginning of a data block, the *data payload* consisting of one or more packets containing the actual data for the current block, and a *data trailer* consisting of one packet used to signal the end of the data block.

The packet size parameter sets the size of the packets that the camera will use when it sends the data payload via the selected stream channel. The value is in bytes. The value does not affect the leader and trailer size, which use a total of 36 bytes, and the last data packet may be a smaller size. The payload size will be packet size minus 36 bytes.

The packet size parameter should always be set to the maximum size that your network adapter and network switches (if used) can handle.

**Inter-packet Delay** (read/write)

Sets the delay in ticks between the packets sent by the camera. Applies to the selected stream channel. Increasing the inter-packet delay will decrease the camera's effective data transmission rate and will thus decrease the network bandwidth used by the camera.

In the current camera implementation, one tick = 8 ns. To check the tick frequency, you can read the Gev Timestamp Tick Frequency parameter value. This value indicates the number of clock ticks per second.

When setting the time interval for the inter-packet delay, make sure that the time interval for the packet timeout is set to a higher value.

**Frame Transmission Delay** (read/write)

Sets a delay in ticks (one tick = 8 ns) between when a camera would normally begin transmitting an acquired frame and when it actually begins transmission. This parameter should be set to zero in most normal situations.

If you have many cameras in your network and you will be simultaneously triggering image acquisition on all of them, you may find that your network switch or network adapter is overwhelmed if all of the cameras simultaneously begin to transmit image data at once. The frame transmission delay parameter can be used to stagger the start of image data transmission from each camera.

**Bandwidth Assigned** (read only)

Indicates the bandwidth in bytes per second that will be used by the camera to transmit image and chunk feature data and to handle resends and control data transmissions. The value of this parameter is a result of the packet size and the inter-packet delay parameter settings.

In essence, the bandwidth assigned is calculated this way:

$$\text{Bandwidth Assigned} = \frac{\frac{\text{X Packets}}{\text{Frame}} \times \frac{\text{Y Bytes}}{\text{Packet}}}{\left[\frac{\text{X Packets}}{\text{Frame}} \times \frac{\text{Y Bytes}}{\text{Packet}} \times \frac{8\ \text{ns}}{\text{Byte}}\right] + \left[\left(\frac{\text{X Packets}}{\text{Frame}} - 1\right) \times (\text{IPD} \times 8\ \text{ns})\right]}$$

Where: X = number of packets needed to transmit the frame

Y = number of bytes in each packet

IPD = Inter-packet Delay setting in ticks (with a tick set to the 8 ns standard)

When considering this formula, you should know that on a Gigabit network it takes one tick to transmit one byte. Also, be aware that the formula has been simplified for easier understanding.

**Bandwidth Reserve** (read/write)

Used to reserve a portion of the assigned bandwidth for packet resends and for the transmission of control data between the camera and the host PC. The setting is expressed as a percentage of the Bandwidth Assigned parameter. For example, if the Bandwidth Assigned parameter indicates that

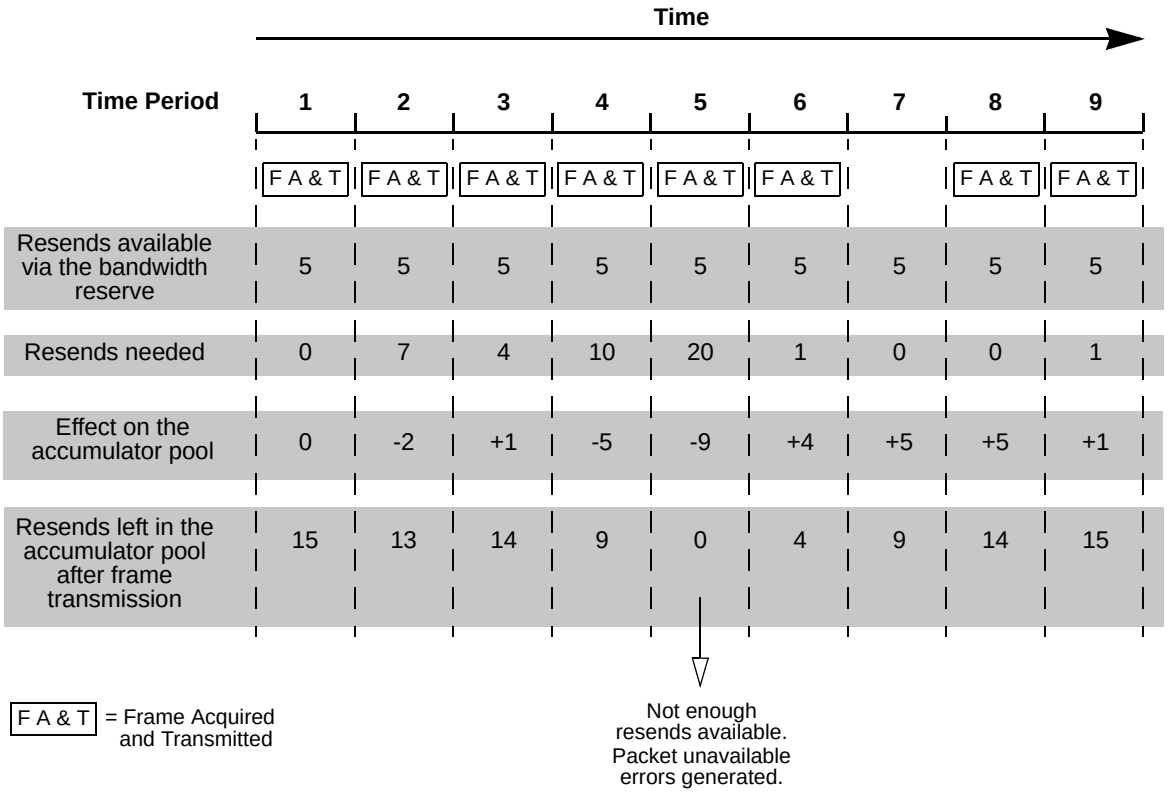
30 MByte/s have been assigned to the camera and the Bandwidth Reserve parameter is set to 5%, then the bandwidth reserve will be 1.5 MByte/s.

**Bandwidth Reserve Accumulation** (read/write)

A software device called the bandwidth reserve accumulator is designed to handle unusual situations such as a sudden EMI burst that interrupts an image transmission. If this happens, a larger than normal number of packet resends may be needed to properly transmit a complete image. The accumulator is basically an extra pool of resends that the camera can use in unusual situations.

The Bandwidth Reserve Accumulation parameter is a multiplier used to set the maximum number of resends that can be held in the "accumulator pool." For example, assume that the current bandwidth reserve setting for your camera is 5% and that this reserve is large enough to allow up to 5 packet resends during a frame period. Also assume that the Bandwidth Reserve Accumulation parameter is set to 3. With these settings, the accumulator pool can hold a maximum of 15 resends (i.e., the multiplier times the maximum number of resends that could be transmitted in a frame period). Note that with these settings, 15 will also be the starting number of resends within the accumulator pool.

The chart on the next page and the numbered text below it show an example of how the accumulator would work with these settings. The chart and the text assume that you are using an external trigger to trigger image acquisition. The example also assumes that the camera is operating in a poor environment, so many packets are lost and many resends are required. The numbered text is keyed to the time periods in the chart.


Time
Time Period
1
2
3
4
5
6
7
8
9
F A & T
Resends available via the bandwidth reserve
5 5 5 5 5 5 5 5 5
Resends needed
0 7 4 10 20 1 0 0 1
Effect on the accumulator pool
0 -2 +1 -5 -9 +4 +5 +5 +1
Resends left in the accumulator pool after frame transmission
15 13 14 9 0 4 9 14 15
F A & T = Frame Acquired and Transmitted
Not enough resends available. Packet unavailable errors generated.

(1) You trigger image acquisition and during this time period, the camera acquires and transmits a frame. The bandwidth reserve setting would allow 5 resends during this time period, but no resends are needed. The accumulator pool started with 15 resends available and remains at 15.

(2) You trigger image acquisition and during this time period, the camera acquires and transmits a frame. The bandwidth reserve setting would allow 5 resends during this time period, but 7 resends are needed. The 5 resends available via the bandwidth reserve are used and 2 resends are used from the accumulator pool. The accumulator pool is drawn down to 13.

(3) You trigger image acquisition and during this time period, the camera acquires and transmits a frame. The bandwidth reserve setting would allow 5 resends during this time period and 4 resends are needed. The 4 resends needed are taken from the resends available via the bandwidth reserve. The fifth resend available via the bandwidth reserve is not needed, so it is added to the accumulator pool and brings the pool to 14.

(4) You trigger image acquisition and during this time period, the camera acquires and transmits a frame. The bandwidth reserve setting would allow 5 resends during this time period, but 10 resends are needed. The 5 resends available via the bandwidth reserve are used and 5 resends are used from the accumulator pool. The accumulator pool is drawn down to 9.

(5) You trigger image acquisition and during this time period, the camera acquires and transmits a frame. The bandwidth reserve setting would allow 5 resends during this time period, but 20 resends are needed. The 5 resends available via the bandwidth reserve are used. To complete all of the needed resends, 15 resends would be required from the accumulator pool, but the pool only has 9 resends. So the 9 resends in the pool are used and 6 resend requests are answered with a "packet unavailable" error code. The accumulator pool is reduced to 0.

(6) You trigger image acquisition and during this time period, the camera acquires and transmits a frame. The bandwidth reserve setting would allow 5 resends during this time period and 1 resend is needed. The 1 resend needed is taken from the resends available via the bandwidth reserve. The other 4 resends available via the bandwidth reserve are not needed, so they are added to the accumulator pool and they bring the pool up to 4.

(7) During this time period, you do not trigger image acquisition. You delay triggering acquisition for the period of time that would normally be needed to acquire and transmit a single image. The current camera settings would allow 5 resends to occur during this period of time. But since no data is transmitted, no resends are required. The 5 resends that could have occurred are added to the accumulator pool and they bring the pool up to 9.

(8) You trigger image acquisition and during this time period, the camera acquires and transmits a frame. The bandwidth reserve setting would allow 5 resends during this time period, but no resends are needed. The 5 resends available via the bandwidth reserve are not needed, so they are added to the accumulator pool and they bring the pool up to 14.

(9) You trigger image acquisition and during this time period, the camera acquires and transmits a frame. The bandwidth reserve setting would allow 5 resends during this time period and 1 resend is needed. The 1 resend needed is taken from the resends available via the bandwidth reserve. The other 4 resends available via the bandwidth reserve are not needed, so they are added to the accumulator pool. Note that with the current settings, the accumulator pool can only hold a maximum of 15 resends. So the pool is now 15.

**Frame Max Jitter** (read only)

If the Bandwidth Reserve Accumulation parameter is set to a high value, the camera can experience a large burst of data resends during transmission of a frame. This burst of resends will delay the start of transmission of the next acquired frame. The Frame Max Jitter parameter indicates the maximum time in ticks (one tick = 8 ns) that the next frame transmission could be delayed due to a burst of resends.

**Device Max Throughput** (read only)

Indicates the maximum amount of data (in bytes per second) that the camera could generate given its current settings and an ideal world. This parameter gives no regard to whether the GigE network has the capacity to carry all of the data and does not consider any bandwidth required for resends. In essence, this parameter indicates the maximum amount of data the camera could generate with no network restrictions.

If the Acquisition Frame Rate abs parameter has been used to set the camera’s frame rate, the camera will use this frame rate setting to calculate the device max throughput. If software or hardware triggering is being used to control the camera’s frame rate, the maximum frame rate allowed with the current camera settings will be used to calculate the device max throughput.

**Device Current Throughput** (read only)

Indicates the actual bandwidth (in bytes per second) that the camera will use to transmit image data and chunk data given the current area of interest settings, chunk feature settings, and the pixel format setting.

If the Acquisition Frame Rate abs parameter has been used to set the camera's frame rate, the camera will use this frame rate setting to calculate the device current throughput. If software or hardware triggering is being used to control the camera's frame rate, the maximum frame rate allowed with the current camera settings will be used to calculate the device current throughput.

Note that the Device Current Throughput parameter indicates the bandwidth needed to transmit the actual image data and chunk data. The Bandwidth Assigned parameter, on the other hand, indicates the bandwidth needed to transmit image data and chunk data plus the bandwidth reserved for retries and the bandwidth needed for any overhead such as leaders and trailers.

**Resulting Frame Rate** (read only)

Indicates the maximum allowed frame acquisition rate (in frames per second) given the current camera settings. The parameter takes the current area of interest, exposure time, and bandwidth settings into account.

If the Acquisition Frame Rate abs parameter has been used to set the camera's frame rate, the Resulting Frame Rate parameter will show the Acquisition Frame Rate abs parameter setting. If software or hardware triggering is being used to control the camera's frame rate, the Resulting Frame Rate parameter will indicate the maximum frame rate allowed given the current camera settings.

You can read or set the camera's network related parameter values from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the selector and the parameter values:

```
// Payload Size
int64_t payloadSize = Camera.PayloadSize.GetValue();

// GevStreamChannelSelector
Camera.GevStreamChannelSelector.SetValue
( GevStreamChannelSelector_StreamChannel0 );

// PacketSize
Camera.GevSCPSPacketSize.SetValue( 1500 );

// Inter-packet Delay
Camera.GevSCPD.SetValue( 1000 );

// Frame-transmission Delay
Camera.GevSCFTD.SetValue( 1000 );

// Bandwidth Reserve
Camera.GevSCBWR.SetValue( 10 );
```

```
// Bandwidth Reserve Accumulation
Camera.GevSCBWRA.SetValue( 10 );

// Frame Jitter Max
int64_t jitterMax = Camera.GevSCFJM.GetValue();

// Device Max Throughput
int64_t maxThroughput = Camera.GevSCDMT.GetValue();

// Device Current Throughput
int64_t currentThroughput = Camera.GevSCDCT.GetValue();

// Resulting Framerate
double resultingFps = Camera.ResultingFrameRateAbs.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

# 5.2 Managing Bandwidth When Multiple Cameras Share a Single Network Path

If you are using a single camera on a GigE network, the problem of managing bandwidth is simple. The network can easily handle the bandwidth needs of a single camera and no intervention is required. A more complicated situation arises if you have multiple cameras connected to a single network adapter as shown in Figure 14.

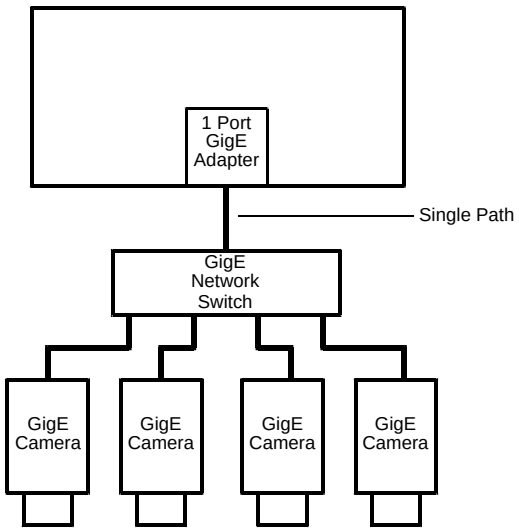



Fig. 14: Multiple Cameras on a Network

One way to manage the situation where multiple cameras are sharing a single network path is to make sure that only one of the cameras is acquiring and transmitting images at any given time. The data output from a single camera is well within the bandwidth capacity of the single path and you should have no problem with bandwidth in this case.

If you want to acquire and transmit images from several cameras simultaneously, however, you must determine the total data output rate for all the cameras that will be operating simultaneously and you must make sure that this total does not exceed the bandwidth of the single path (125 MByte/s).

An easy way to make a quick check of the total data output from the cameras that will operate simultaneously is to read the value of the Bandwidth Assigned parameter for each camera. This parameter indicates the camera’s gross data output rate in bytes per second with its current settings. If the sum of the bandwidth assigned values is less than 125 MByte/s, the cameras should be able to operate simultaneously without problems. If it is greater, you must lower the data output rate of one or more of the cameras.

You can lower the data output rate on a camera by using the Inter-packet Delay parameter. This parameter adds a delay between the transmission of each packet from the camera and thus slows the data transmission rate of the camera. The higher the inter-packet delay parameter is set, the greater the delay between the transmission of each packet will be and the lower the data transmission rate will be. After you have adjusted the Inter-packet Delay parameter on each camera, you can check the sum of the Bandwidth Assigned parameter values and see if the sum is now less than 125 MByte/s.

### 5.2.1 A Procedure for Managing Bandwidth

In theory, managing bandwidth sharing among several cameras is as easy as adjusting the inter-packet delay. In practice, it is a bit more complicated because you must consider several factors when managing bandwidth. The procedure below outlines a structured approach to managing bandwidth for several cameras.

The objectives of the procedure are:

- To optimize network performance.
- To determine the bandwidth needed by each camera for image data transmission.
- To determine the bandwidth actually assigned to each camera for image data transmission.
- For each camera, to make sure that the actual bandwidth assigned for image data transmission matches the bandwidth needed.
- To make sure that the total bandwidth assigned to all cameras does not exceed the network's bandwidth capacity.
- To make adjustments if the bandwidth capacity is exceeded.

**Step 1 - Improve the Network Performance.**

If you use, as recommended, the Basler performance driver with an Intel PRO network adapter or a compatible network adapter, the network parameters for the network adapter are automatically optimized and need not be changed.

If you use the Basler filter driver and have already set network parameters for your network adapter during the installation of the Basler pylon software, continue with step two. Otherwise, open the **Network Connection Properties** window for your network adapter and check the following network parameters:

- If you use an Intel PRO network adapter: Make sure the **Receive Descriptors** parameter is set to its maximum value and the **Interrupt Moderation Rate** parameter is set to **Extreme**.

  Also make sure the **Speed and Duplex Mode** parameter is set to **Auto Detect**.
- If you use a different network adapter, see whether parameters are available that will allow setting the number of receive descriptors and the number of CPU interrupts. The related parameter names may differ from the ones used for the Intel PRO adapters. Also, the way of setting the parameters may be different. You may, e.g., have to use a parameter to set a low number for the interrupt moderation and then use a different parameter to enable the interrupt moderation.

  If possible, set the number of receive descriptors to a maximum value and set the number of

CPU interrupts to a low value.

If possible, also set the parameter for speed and duplex to auto.

Contact Basler technical support if you need further assistance.

**Step 2 - Set the Packet Size parameter on each camera as large as possible.**

Using the largest possible packet size has two advantages, it increases the efficiency of network transmissions between the camera and the PC and it reduces the time required by the PC to process incoming packets. The largest packet size setting that you can use with your camera is determined by the largest packet size that can be handled by your network. The size of the packets that can be handled by the network depends on the capabilities and settings of the network adapter you are using and on capabilities of the network switch you are using.

Unless you have already set the packet size for your network adapter during the installation of the Basler pylon software, check the documentation for your adapter to determine the maximum packet size (sometimes called “frame” size) that the adapter can handle. Many adapters can handle what is known as “jumbo packets” or "jumbo frames". These are packets with a maximum size of 16 kB. Once you have determined the maximum size packets the adapter can handle, make sure that the adapter is set to use the maximum packet size.

Next, check the documentation for your network switch and determine the maximum packet size that it can handle. If there are any settings available for the switch, make sure that the switch is set for the largest packet size possible.

Now that you have set the adapter and switch, you can determine the largest packet size the network can handle. The device with the smallest maximum packet size determines the maximum allowed packet size for the network. For example, if the adapter can handle 8 kB packets and the switch can handle 6 kB packets, then the maximum for the network is 6 kB packets.

Once you have determined the maximum packet size for your network, set the value of the Packet Size parameter on each camera to this value.

The manufacturer’s documentation sometimes makes it difficult to determine the maximum packet size for a device, especially network switches. There is a "quick and dirty" way to check the maximum packet size for your network with its current configuration:

1. Open the pylon Viewer, select a camera, and set the Packet Size parameter to a low value (1 kB for example).
2. Use the Continuous Shot mode to capture several images.
3. Gradually increase the value of the Packet Size parameter and capture a few images after each size change.
4. When your Packet Size setting exceeds the packet size that the network can handle, the viewer will lose the ability to capture images. (When you use Continuous Shot, the viewer’s status bar will indicate that it is acquiring images, but the image in the viewing area will appear to be frozen.)

**Step 3 - Set the Bandwidth Reserve parameter for each camera.**

The Bandwidth Reserve parameter setting for a camera determines how much of the bandwidth assigned to that camera will be reserved for lost packet resends and for asynchronous traffic such as commands sent to the camera. If you are operating the camera in a relatively EMI free environment, you may find that a bandwidth reserve of 2% or 3% is adequate. If you are operating in an extremely noisy environment, you may find that a reserve of 8% or 10% is more appropriate.

**Step 4 - Calculate the "data bandwidth needed" by each camera.**

The objective of this step is to determine how much bandwidth (in Byte/s) each camera needs to transmit the image data that it generates. The amount of data bandwidth a camera needs is the product of several factors: the amount of data included in each image, the amount of chunk data being added to each image, the "packet overhead" such as packet leaders and trailers, and the number of frames the camera is acquiring each second.

For each camera, you can use the two formulas below to calculate the data bandwidth needed. To use the formulas, you will need to know the current value of the Payload Size parameter and the Packet Size parameter for each camera. You will also need to know the frame rate (in frames/s) at which each camera will operate.

$$\text{Bytes/Frame} = \left[ \left\lceil \frac{\text{Payload Size}}{\text{Packet Size}} \right\rceil^{1} \times \text{Packet Overhead} \right] + \lceil \text{Payload Size} \rceil^{4} + \text{Leader Size} + \text{Trailer Size}$$

$$\text{Data Bandwidth Needed} = \text{Bytes/Frame} \times \text{Frames/s}$$

Where:

Packet Overhead = 72 (for a GigE network)
78 (for a 100 MBit/s network)

Leader Size = Packet Overhead + 36 (if chunk mode is not active)
Packet Overhead + 12 (if chunk mode is active)

Trailer Size = Packet Overhead + 8

$\lceil x \rceil^{1}$ means round up x to the nearest integer

$\lceil x \rceil^{4}$ means round up x to the nearest multiple of 4

**Step 5 - Calculate “data bandwidth assigned” to each camera.**

For each camera, there is a parameter called Bandwidth Assigned. This read only parameter indicates the total bandwidth that has been assigned to the camera. The Bandwidth Assigned parameter includes both the bandwidth that can be used for image data transmission plus the bandwidth that is reserved for packet resents and camera control signals. To determine the “data bandwidth assigned,” you must subtract out the reserve.

You can use the formula below to determine the actual amount of assigned bandwidth that is available for data transmission. To use the formula, you will need to know the current value of the Bandwidth Assigned parameter and the Bandwidth reserve parameter for each camera.

$$\text{Data Bandwidth Assigned} = \text{Bandwidth Assigned} \times \frac{100 - \text{Bandwidth Reserved}}{100}$$

**Step 6 - For each camera, compare the data bandwidth needed with the data bandwidth assigned.**

For each camera, you should now compare the data bandwidth assigned to the camera (as determined in step 4) with the bandwidth needed by the camera (as determined in step 3).

For bandwidth to be used most efficiently, the data bandwidth assigned to a camera should be equal to or just slightly greater than the data bandwidth needed by the camera. If you find that this is the situation for all of the cameras on the network, you can go on to step 6 now. If you find a camera that has much more data bandwidth assigned than it needs, you should make an adjustment.

To lower the amount of data bandwidth assigned, you must adjust a parameter called the Inter-packet Delay. If you increase the Inter-packet Delay parameter value on a camera, the data bandwidth assigned to the camera will decrease. So for any camera where you find that the data bandwidth assigned is much greater then the data bandwidth needed, you should do this:

1. Raise the setting for the Inter-packet delay parameter for the camera.
2. Recalculate the data bandwidth assigned to the camera.
3. Compare the new data bandwidth assigned to the data bandwidth needed.
4. Repeat 1, 2, and 3 until the data bandwidth assigned is equal to or just greater than the data bandwidth needed.

If you increase the inter-packet delay to lower a camera's data output rate there is something that you must keep in mind. When you lower the data output rate, you increase the amount of time that the camera needs to transmit an acquired frame (image). Increasing the frame transmission time can restrict the camera's maximum allowed frame rate.

**Step 7 - Check that the total bandwidth assigned is less than the network capacity.**

1. For each camera, determine the current value of the Bandwidth Assigned parameter. The value is in Byte/s. (Make sure that you determine the value of the Bandwidth Assigned parameter after you have made any adjustments described in the earlier steps.)
2. Find the sum of the current Bandwidth Assigned parameter values for all of the cameras.

If the sum of the Bandwidth Assigned values is less than 125 MByte/s for a GigE network or 12.5 M/Byte/s for a 100 Bit/s network, the bandwidth management is OK.

If the sum of the Bandwidth Assigned values is greater than 125 MByte/s for a GigE network or 12.5 M/Byte/s for a 100 Bit/s network, the cameras need more bandwidth than is available and you must make adjustments. In essence, you must lower the data bandwidth needed by one or more of the

cameras and then adjust the data bandwidths assigned so that they reflect the lower bandwidth needs.

You can lower the data bandwidth needed by a camera either by lowering its frame rate or by decreasing the size of the area of interest (AOI). Once you have adjusted the frame rates and/or AOI settings on the cameras, you should repeat steps 2 through 6.

For more information about the camera's maximum allowed frame transmission rate, see Section 9.12 on page 144.

For more information about the AOI, see Section 11.6 on page 185.

# 6 Camera Functional Description

This chapter provides an overview of the camera’s functionality from a system perspective. The overview will aid your understanding when you read the more detailed information included in the later chapters of the user’s manual.

## 6.1 Overview

Each camera provides features such as a full frame shutter and electronic exposure time control.

Exposure start and exposure time can be controlled by parameters transmitted to the camera via the Basler pylon API and the GigE interface. There are also parameters available to set the camera for single frame acquisition or continuous frame acquisition.

Exposure start can also be controlled via an externally generated "frame start trigger" (ExFSTrig) signal applied to the camera’s input line. The ExFSTrig signal facilitates periodic or non-periodic acquisition start. Modes are available that allow the length of exposure time to be directly controlled by the ExFSTrig signal or to be set for a pre-programmed period of time.

Accumulated charges are read out of the sensor when exposure ends. At readout, accumulated charges are transported from the sensor’s light-sensitive elements (pixels) to the vertical shift registers (see Figure 15 on page 54). The charges from the bottom line of pixels in the array are then moved into a horizontal shift register. Next, the charges are shifted out of the horizontal register. As the charges move out of the horizontal shift register, they are converted to voltages proportional to the size of each charge. Each voltage is then amplified by a Variable Gain Control (VGC) and digitized by an Analog-to-Digital converter (ADC). After each voltage has been amplified and digitized, it passes through an FPGA and into an image buffer. All shifting is clocked according to the camera’s internal data rate. Shifting continues in a linewise fashion until all image data has been read out of the sensor.

The pixel data leaves the image buffer and passes back through the FPGA to an Ethernet controller where it is assembled into data packets. The packets are then transmitted via an Ethernet network to a network adapter in the host PC. The Ethernet controller also handles transmission and receipt of control data such as changes to the camera’s parameters.

The image buffer between the sensor and the Ethernet controller allows data to be read out of the sensor at a rate that is independent of the data transmission rate between the camera and the host computer. This ensures that the data transmission rate has no influence on image quality.

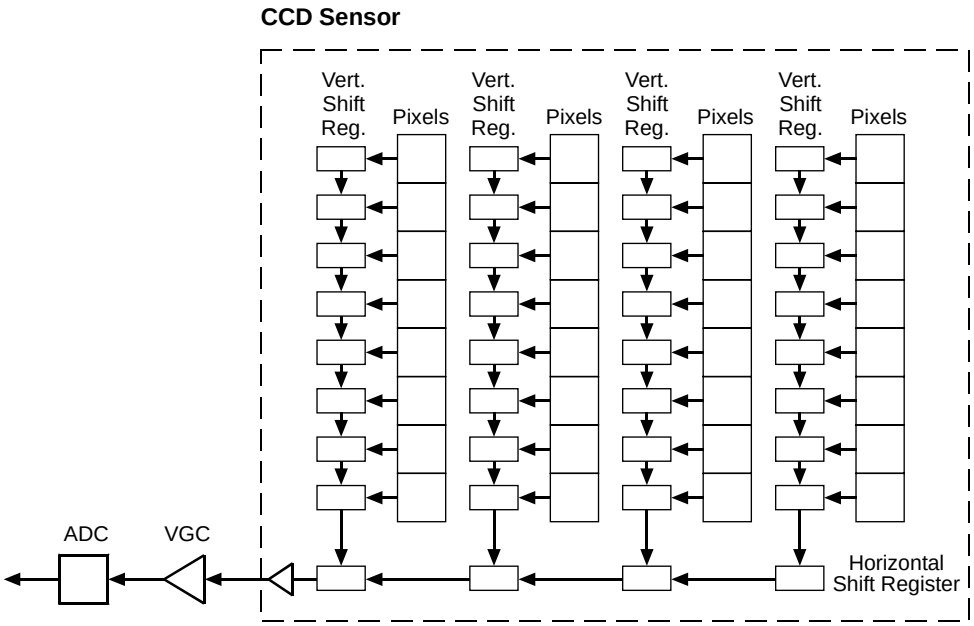



Fig. 15: CCD Sensor Architecture

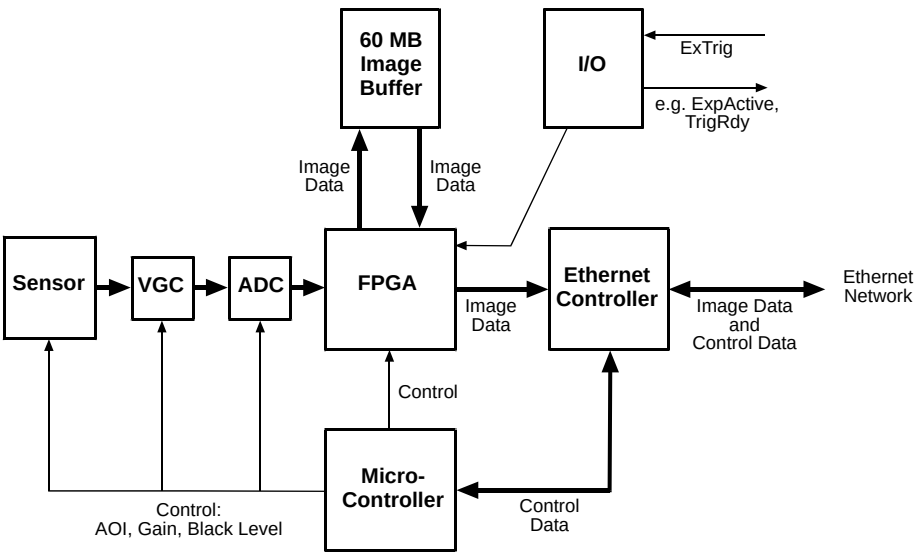



Fig. 16: Camera Block Diagram

# 7 Physical Interface

This chapter provides detailed information, such as pinouts and voltage requirements, for the physical interface on the camera. This information will be especially useful during your initial design-in process.

## 7.1 General Description of the Connections

The camera is interfaced to external circuity via connectors located on the back of the housing:

- An 8-pin, RJ-45 jack used to provide a 100/1000 Mbit/s Ethernet connection to the camera. This jack includes a green LED and a yellow LED that indicate the state of the network connection.
- A 12-pin receptacle used to provide access to the camera's I/O lines and to provide power to the camera.

The drawing below shows the location of the two connectors and the LEDs.

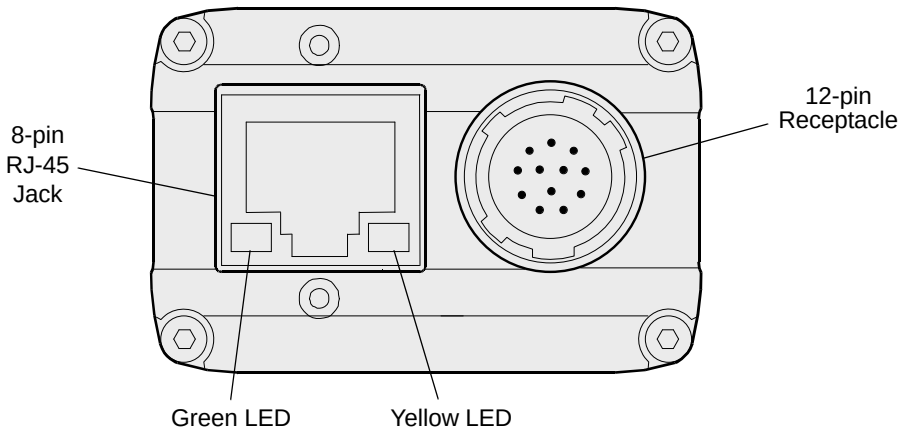



Fig. 17: Camera Connectors and LED

# 7.2 Connector Pin Assignments and Numbering

## 7.2.1 12-pin Receptacle Pin Assignments

The 12 pin receptacle is used to access the physical input line and the physical output line on the camera. It is also used to supply power to the camera. The pin assignments for the receptacle are shown in Table 4.

| Pin | Designation |
|---|---|
| 1 | Camera Power Gnd * |
| 2 | Camera Power Gnd * |
| 3 | I/O Input 1 |
| 4 | Non-functional |
| 5 | I/O Input Gnd |
| 6 | I/O Output 1 |
| 7 | Non-functional |
| 8 | Camera Power VCC ** |
| 9 | Camera Power VCC ** |
| 10 | I/O Output VCC |
| 11 | Non-functional |
| 12 | Non-functional |

Table 4: Pin Assignments for the 12-pin Receptacle

***NOTICE***

Avoid Applying Voltage to the Non-functional Pins.

Applying voltages to the non-functional pins in the 12-pin connector may damage the electronic components in the camera. We recommend that you do not apply signals to any of the non-functional pins.

| | |
|---|---|
| | * Pins 1 and 2 are tied together inside of the camera.<br>** Pins 8 and 9 are tied together inside of the camera.<br>To avoid a voltage drop when there are long wires between your power suppy and the camera, we recommend that you provide camera power VCC through separate wires between your power supply and pins 8 and 9 on the camera. We also recommend that you provide camera power ground through separate wires between your power supply and pins 1 and 2 on the camera. |

Pin numbering for the 12-pin receptacle is as shown in Section 7.2.3 on page 57.

## 7.2.2 RJ-45 Jack Pin Assignments

The 8-pin RJ-45 jack provides Ethernet access to the camera. Pin assignments adhere to the Ethernet standard.

## 7.2.3 Pin Numbering

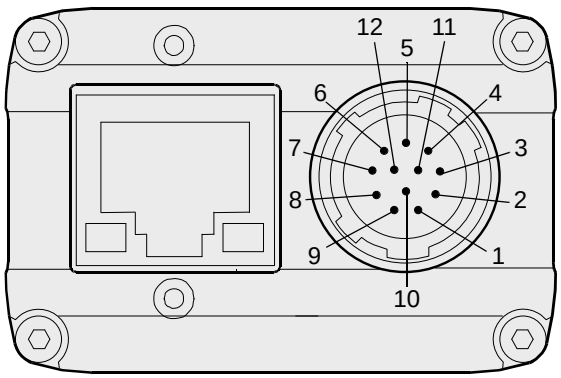



Fig. 18: Pin Numbering for the 12-pin Receptacle

# 7.3 Connector Types

## 7.3.1 8-pin RJ-45 Jack

The 8-pin jack for the camera's Ethernet connection is a standard RJ-45 connector.

The recommended mating connector is any standard 8-pin RJ-45 plug. Cables terminated with screw-lock connectors are available from Basler. Contact your Basler sales representative to order cable assemblies.

Suitable cable assemblies are also available from e.g. Components Express, Inc. and from the Intercon 1 division of Nortech Systems, Inc.

To ensure that you order cables with the correct connectors, note the vertical orientation of the screws before ordering.

**Green and Yellow LEDs**

This RJ-45 jack on the camera includes a green LED and a yellow LED. When the green LED is lit, it indicates that an active network connection is available. When the yellow LED is lit, it indicates that data is being transmitted via the network connection.

## 7.3.2 12-pin Connector

The 12-pin connector on the camera is a Hirose micro receptacle (part number HR10A-10R-12P) or the equivalent.

The recommended mating connector is the Hirose micro plug (part number HR10A-10P-12S) or the equivalent.

# 7.4 Cabling Requirements

## 7.4.1 Ethernet Cables

Use high-quality Ethernet cables. To avoid EMI, the cables must be shielded. Use of category 6 or category 7 cables with S/STP shielding is strongly recommended. As a general rule, applications with longer cables or applications in harsh EMI conditions require higher category cables.

Either a straight-through (patch) or a cross-over Ethernet cable can be used to connect the camera directly to a GigE network adapter in a PC or to a GigE network switch.

Close proximity to strong magnetic fields should be avoided.

## 7.4.2 Standard Power and I/O Cable

| | |
|---|---|
| | The standard power and I/O cable is intended for use if the camera is not connected to a PLC device. If the camera is connected to a PLC device, we recommend using a PLC power and I/O cable rather than the standard power and I/O cable.<br>You can use a PLC power and I/O cable when the camera is not connected to a PLC device, if power for the I/O input is supplied with 24 VDC.<br>See the following section for more information on PLC power and I/O cables. |

A single cable is used to connect power to the camera and to connect to the camera's I/O lines as shown in Figure 19.

The end of the standard power and I/O cable that connects to the camera must be terminated with a Hirose micro plug (part number HR10A-10P-12S) or the equivalent. The cable must be wired to conform with the pin assignments shown in the pin assignment tables.

The maximum length of the standard power and I/O cable is at least 10 meters. The cable must be shielded and must be constructed with twisted pair wire. Use of twisted pair wire is essential to ensure that input signals are correctly received.

Close proximity to strong magnetic fields should be avoided.

The required 12-pin Hirose plug is available from Basler. Basler also offers a cable assembly that is terminated with a 12-pin Hirose plug on one end and unterminated on the other. Contact your Basler sales representative to order connectors or cables.

**NOTICE**

Avoid Applying Voltage to the Non-functional Pins.

Applying voltages to the non-functional pins in the 12-pin connector may damage the electronic components in the camera. We recommend that you do not apply signals to any of the non-functional pins.

**NOTICE**

An Incorrect Plug Can Damage the 12-pin Connector.

The plug on the cable that you attach to the camera's 12-pin connector must have 12 pins. Use of a smaller plug, such as one with 10 pins or 8 pins, can damage the pins in the camera's 12-pin connector.

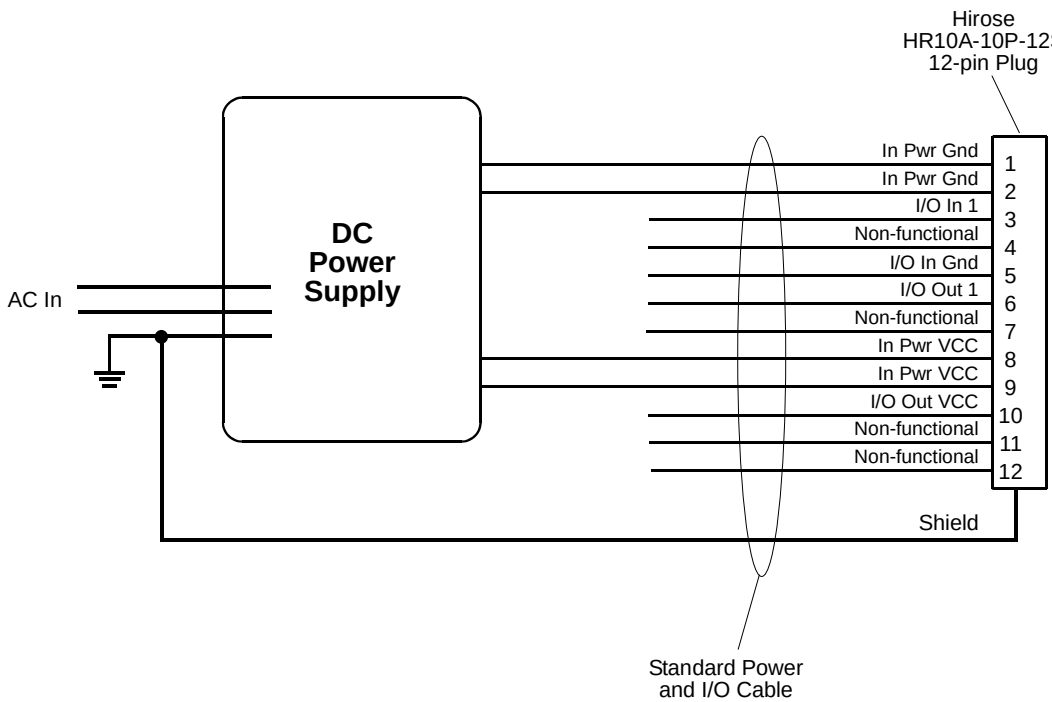



Fig. 19: Standard Power and I/O Cable

| | |
|---|---|
| | To avoid a voltage drop with long power wires, we recommend that you supply camera power VCC through two separate wires between the power supply and the camera as shown in the figure above.<br>We also recommend that you supply camera power ground through two separate wires between the power supply and the camera as shown in the figure. |

## 7.4.3 PLC Power and I/O Cable

As with the standard power and I/O cable described in the previous section, the PLC power and I/O cable is a single cable that connects power to the camera and connects to the camera's I/O lines.

The PLC power and I/O cable adjusts the voltage levels of PLC devices to the voltage levels required by the camera, and it protects the camera against negative voltage and reverse polarity.

Close proximity to strong magnetic fields should be avoided.

| | |
|---|---|
| | We recommend using a PLC power and I/O cable if the camera is connected to a PLC device.<br>You can use a PLC power and I/O cable when the camera is not connected to a PLC device, if power for the I/O input is supplied with 24 VDC. |

Basler offers PLC power and I/O cables with 3 m and 10 m lengths. Each cable is terminated with a 12-pin Hirose plug (HR10A-10P-12S) on the end that connects to the camera. The other end is unterminated. Contact your Basler sales representative to order the cables.

For information about the applicable voltage levels, see Section 7.7.1.1 on page 64.

# 7.5 Camera Power

Camera power must be supplied to the camera's 12-pin connector via the standard power and I/O cable or via the PLC power and I/O cable. Power consumption is as shown in the specification tables in Section 1 of this manual.

***NOTICE***

Voltage Outside of Specified Range Can Cause Damage.

If the voltage of the power to the camera is greater than +30.0 VDC damage to the camera can result. If the voltage is less than +11.3 VDC, the camera may operate erratically.

***NOTICE***

Avoid Applying Voltage to the Non-functional Pins.

Applying voltages to the non-functional pins in the 12-pin connector may damage the electronic components in the camera. We recommend that you do not apply signals to any of the non-functional pins.

***NOTICE***

An Incorrect Plug Can Damage the 12-pin Connector.

The plug on the cable that you attach to the camera's 12-pin connector must have 12 pins. Use of a smaller plug, such as one with 10 pins or 8 pins, can damage the pins in the camera's 12-pin connector.

The following voltage requirements apply to the camera power VCC (pins 8 and 9 of the 12-pin receptacle):

| Voltage | Significance |
|---|---|
| < +11.3 VDC | The camera may operate erratically. |
| +12 to +24 VDC | Recommended operating voltage; < 1 % ripple required. Make sure to use a power supply that supplies power in this voltage range. |
| +30.0 VDC | Absolute maximum; the camera may be damaged when the absolute maximum is exceeded. |

Table 5: Voltage Requirements for the Camera Power VCC

For more information about the 12-pin connector and the power and I/O cables see Section 7.2 on page 56, Section 7.3 on page 58, and Section 7.4 on page 59.

# 7.6 Ethernet GigE Device Information

The camera uses a standard Ethernet GigE transceiver. The transceiver is fully 100/1000 Base-T 802.3 compliant.

# 7.7 Input and Output Lines

## 7.7.1 Input Line

### 7.7.1.1 Voltage Requirements

Different voltage levels apply, depending on whether the standard power and I/O cable or a PLC power and I/O cable is used (see below).

**Voltage Levels When the Standard Power and I/O Cable is Used**

The following voltage requirements apply to the camera's I/O input (pin 3 of the 12-pin receptacle):

| Voltage | Significance |
|---|---|
| +0 to +24 VDC | Recommended operating voltage. |
| +0 to +1.4 VDC | The voltage indicates a logical 0. |
| > +1.4 to +2.2 VDC | Region where the transition threshold occurs; the logical state is not defined in this region. |
| > +2.2 VDC | The voltage indicates a logical 1. |
| +30.0 VDC | Absolute maximum; the camera may be damaged when the absolute maximum is exceeded. |

Table 6: Voltage Requirements for the I/O Input When Using the Standard Power and I/O Cable

### Voltage Levels When a PLC Power and I/O Cable is Used

The following voltage requirements apply to the input of the PLC power and I/O cable. The PLC power and I/O cable will adjust the voltages to the levels required at the camera's I/O input (see Table 4).

| Voltage | Significance |
|---|---|
| +0 to +24 VDC | Recommended operating voltage. |
| +0 to +8.4 VDC | The voltage indicates a logical 0. |
| > +8.4 to +10.4 VDC | Region where the transition threshold occurs; the logical state is not defined in this region. |
| > +10.4 VDC | The voltage indicates a logical 1. |
| +30.0 VDC | Absolute maximum; the camera may be damaged when the absolute maximum is exceeded. |

Table 7: Voltage Requirements for the I/O Input When Using a PLC Power and I/O Cable

### 7.7.1.2 Line Schematic

The camera is equipped with one physical input line designated as Input Line 1. The input line is accessed via the 12-pin receptacle on the back of the camera.

As shown in the I/O line schematic, the input line is opto-isolated. See the previous section for input voltages and their significances. The absolute maximum input voltage is +30.0 VDC. The current draw for the input line is between 5 and 15 mA.

Figure 20 shows an example of a circuit you can use to input a signal into the camera.

By default, Input Line 1 is assigned to receive an external hardware trigger (ExTrig) signal that can be used to control the start of image acquisition.

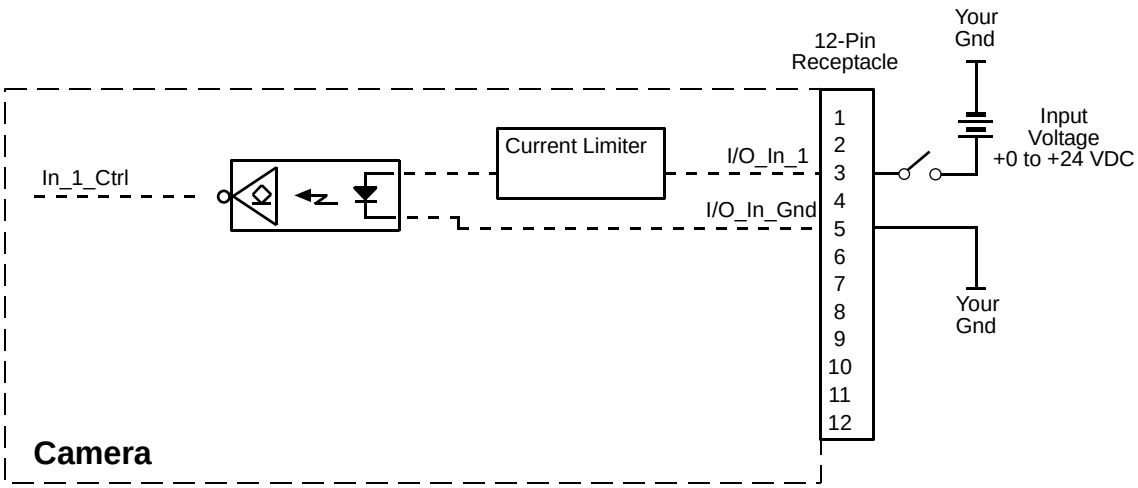



Fig. 20: Voltage Input Circuit

For more information about the input line pin assignment and pin numbering, see Section 7.2 on page 56.

For more information about how to use an ExTrig signal to control image acquisition, see Section 9.4.5 on page 96, Section 9.5.3 on page 104 and Section 9.6.3 on page 115.

For more information about configuring the input line, see Section 8.1 on page 71.

# 7.7.2 Output Line

## 7.7.2.1 Voltage Requirements

The following voltage requirements apply to the I/O output VCC (pin 10 of the 12-pin receptacle):

| Voltage | Significance |
|---|---|
| < +3.3 VDC | The I/O output may operate erratically. |
| +3.3 to +24 VDC | Recommended operating voltage. |
| +30.0 VDC | Absolute maximum; the camera may be damaged if the absolute maximum is exceeded. |

Table 8: Voltage Requirements for the I/O Output VCC

## 7.7.2.2 Line Schematic

The camera is equipped with one physical output line designated as Output Line 1. The output line is accessed via the 12-pin receptacle on the back of the camera.

As shown in the I/O schematic, the output line is opto-isolated. See the previous section for the recommended operating voltage. The absolute maximum voltage is +30.0 VDC. The maximum current allowed through the output circuit is 50 mA.

A conducting transistor means a logical one and a non-conducting transistor means a logical zero.

Figure 21 shows a schematic circuit you can use to monitor the output line with a voltage signal.

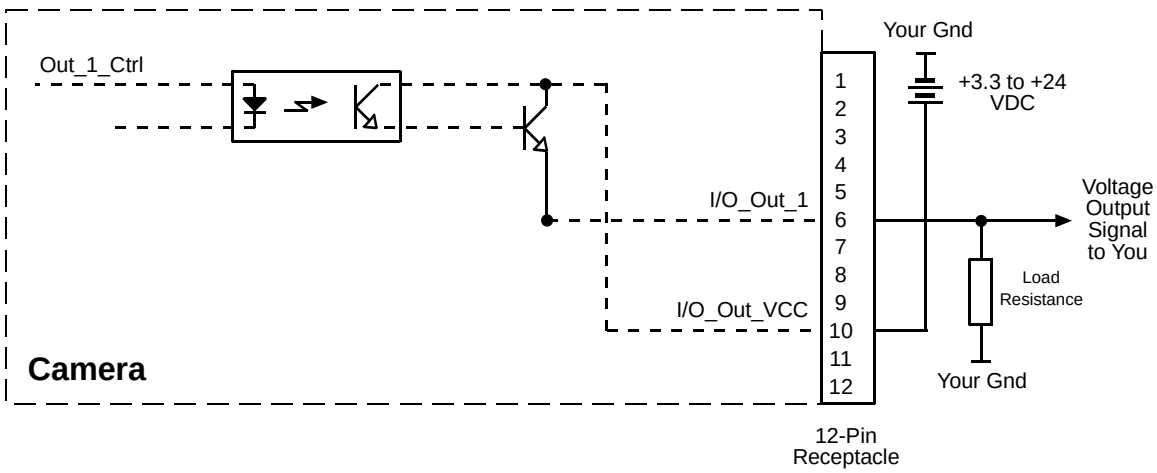



Fig. 21: Typical Voltage Output Circuit

By default, the camera's exposure active (ExpAc) signal is assigned to Output Line 1. The exposure active signal indicates when exposure is taking place.

The assignment of camera output signals to the physical output line can be changed by the user.

For more information about the output line pin assignment and pin numbering, see Section 7.2 on page 56.

For more information about the exposure active signal, see Section Section 9.10.1 on page 135.

For more information about assigning camera output signals to the physical output line, see Section 8.2.1 on page 73.

## 7.7.3 Output Line Response Time

Response times for the output line on the camera are as defined below.

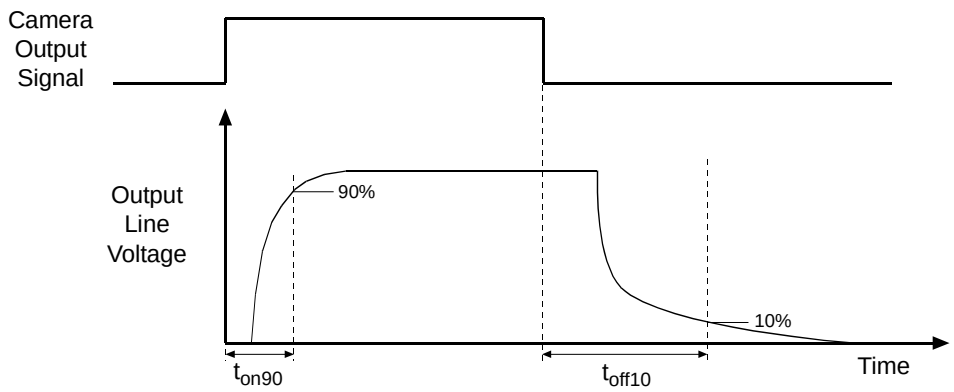



Fig. 22: Output Line Response Times

$t_{on90}$: Time (µs) from switching on the signal until the voltage has reached 90 % of its final level.

$t_{off10}$: Time (µs) from switching off the signal until the voltage has dropped to 10 % of its original level.

| | |
|---|---|
| | The response time values for the output line on your camera will depend on the load current and the applied voltage of your specific application. In addition, the exact values can vary between individual cameras. |

As an example, $t_{on90}$ and $t_{off10}$ were measured for a specific camera, for load currents of 5 mA and 50 mA, and voltages between 3.3 V and 24 V. The results are shown on the figure below.

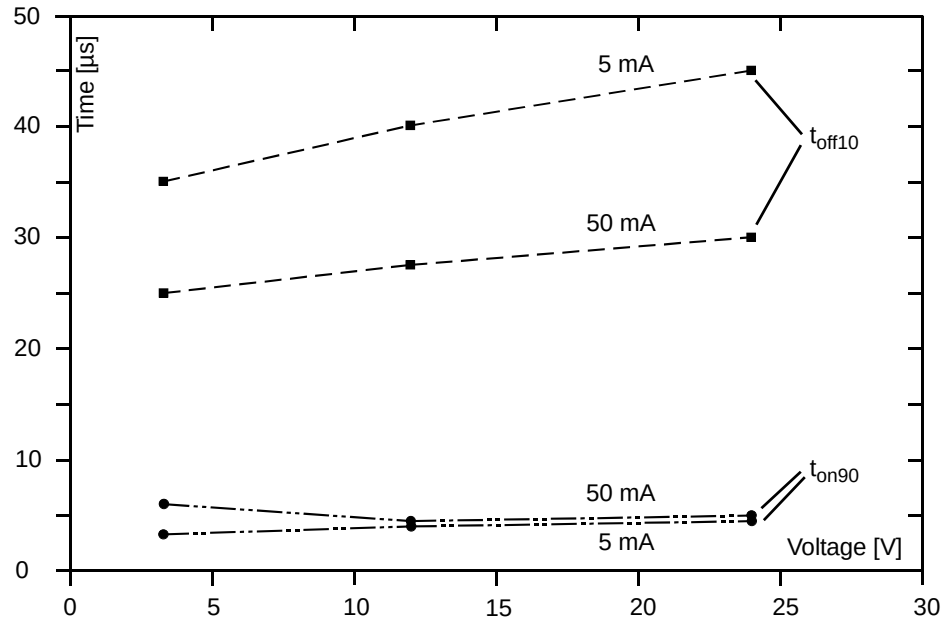



Fig. 23: Dependence of $t_{on90}$ and $t_{off10}$ on Voltage, for Different Load Currents; Measured for an Individual Camera as an Example

Some general tendencies can be seen from the figure:

- $t_{off10}$ increases as the voltage increases and as the load current decreases
- $t_{on90}$ increases as the voltage and the load current increase
- The effects due to different voltages and load currents are more pronounced on $t_{off1}$ than on $t_{on90}$.

# 8 I/O Control

This section describes how to configure the camera's physical input line and the physical output line. It also provides information about monitoring the state of the input and output line.

For more detailed information about the physical and electrical characteristics of the input and output line, see Section 7.7 on page 64.

## 8.1 Configuring the Input Line

### 8.1.1 Assigning the Input Line to Receive a Hardware Trigger Signal

You can assign the camera's input line to receive external hardware trigger (ExTrig) signals. The incoming ExTrig signals can then be used to control image acquisition.

Section 9.4.5.2 on page 97, Section 9.5.3.4 on page 107 and Section 9.6.3.4 on page 119 explain how to configure the camera to react to a hardware trigger signal and how to assign the input line to receive the hardware trigger signal.

The default line assignments depend on the image acquisition control mode:

- Standard mode:

  By default, physical input line 1 is assigned to receive an ExTrig signal to serve as the frame start trigger.
- Legacy mode:

  By default, physical input line 1 is assigned to receive the ExTrig signal to serve as the acquisition start trigger.

## 8.1.2 Using an Unassigned Input Line to Receive a User Input Signal

You can use the input line to receive your own, user-generated input signal. The electrical characteristics of your input signal must meet the requirements shown in the Physical Interface section of this manual.

You can use the Line Status or Line Status All parameters to monitor the state of the input line that is receiving the user-defined signal.

| | |
|---|---|
| | When the input line is assigned to receive an ExTrig input signal the input line can't be used to receive a user-designed input signal. |

For more information about using the Line Status and Line Status All parameters, see Section 8.3.1 on page 81 and Section 8.3.2 on page 81.

# 8.2 Configuring the Output Line

## 8.2.1 Assigning a Camera Output Signal to the Physical Output Line

You can use the camera's output signal assignment capability to assign one of the camera's standard output signals as the source signal for the physical output line. The camera has a variety of standard output signals available including:

- Acquisition Trigger Wait (only available when the image acquisition control is set to standard mode)
- Trigger Ready
- Exposure Active
- Timer 1

You can also designate the output line as "user settable". If the output line is designated as user settable, you can use the camera's API to set the state of the line as desired.

To assign an output signal to the output line or to designate the line as user settable:

- Use the Line Selector to select Output Line 1.
- Set the value of the Line Source Parameter to one of the available output signals or to user settable. This will set the source signal for the output line

By default, the Exposure Active signal is assigned to Output Line 1.

You can set the Line Selector and the Line Source parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.LineSelector.SetValue( LineSelector_Out1 );
Camera.LineSource.SetValue( LineSource_ExposureActive );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

For more information about setting the state of user settable output signals, see Section 8.2.2 on page 74.

For more information about working with the timer output signal, see Section 8.2.4 on page 76

For more information about the exposure active signal, see Section 9.10.1 on page 135.

## 8.2.2 Setting the State of the User Settable Output Line

As mentioned in the previous section, you can designate the user output line as "user settable". Once you have designated the output line as user settable, you can use camera parameters to set the state of the line.

### Setting the State of the User Settable Output Line

To set the state of the single user settable output line:

- After it was designated as user settable, use the User Output Selector to select output line 1.
- Set the value of the User Output Value parameter to true (high) or false (low). This will set the state of the selected line.

You can set the Output Selector and the User Output Value parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to designate output line 1 as user settable and setting the state of the output line:

```
Camera.LineSelector.SetValue( LineSelector_Out1 );
Camera.LineSource.SetValue( LineSource_UserOutput );
Camera.UserOutputSelector.SetValue( UserOutputSelector_UserOutput1 );
Camera.UserOutputValue.SetValue( true );
bool currentUserOutput1State = Camera.UserOutputValue.GetValue( );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

If you have the invert function enabled on the output line that is designated as user settable, the user setting sets the state of the line before the inverter.

### 8.2.3 Setting the Output Line for Invert

You can set the output line to invert or not to invert the outgoing signal. To set the invert function on the output line:

- Use the Line Selector to select output line 1.
- Set the value of the Line Inverter parameter to true to enable inversion on the selected line and to false to disable inversion.

You can set the Line Selector and the Line Inverter parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
// Enable the inverter on output line 1
Camera.LineSelector.SetValue( LineSelector_Out1 );
Camera.LineInverter.SetValue( true );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.For more information about the pylon Viewer, see Section 3.1 on page 25.

## 8.2.4 Working with the Timer

The camera has a timer output signal available: Timer 1. As shown in Figure 24, the timer works as follows:

- A trigger source event occurs that starts the timer.
- A delay period begins to expire.
- When the delay expires, the timer signal goes high and a duration period begins to expire.
- When the duration period expires, the timer signal goes low.

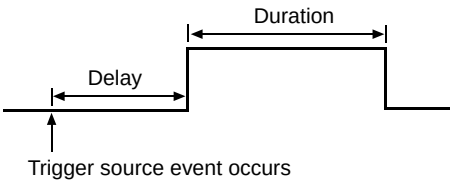



Fig. 24: Timer Signal

Currently, the only trigger source event available to start the timer is "exposure active". In other words, you can use exposure start to trigger the start of the timer.

If you require the timer signal to be high when the timer is triggered and to go low when the delay expires, simply set the output line to invert.

### 8.2.4.1 Setting the Trigger Source for the Timer

To set the trigger source for the timer:

- Use the Timer Selector to select timer 1.
- Set the value of the Timer Trigger Source parameter to exposure active. This will set the selected timer to use the start of exposure to begin the timer.

You can set the Trigger Selector and the Timer Trigger Source parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.TimerSelector.SetValue( TimerSelector_Timer1 );
Camera.TimerTriggerSource.SetValue( TimerTriggerSource_ExposureStart );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

### 8.2.4.2 Setting a Timer Delay Time

There are two ways to set the delay time for the timer: by setting "raw" values or by setting an "absolute value". You can use whichever method you prefer to set the delay time.

#### Setting the Delay with Raw Values

When the delay time for the timer is set using "raw" values, the delay time will be determined by a combination of two elements. The first element is the value of the Timer Delay Raw parameter, and the second element is the Timer Delay Time Base. The delay time is the product of these two elements:

Delay Time = (Timer Delay Raw Parameter Value) x (Timer Delay Time Base)

By default, the Timer Delay Time Base is fixed at 1 µs. Typically, the delay time is adjusted by setting the Timer Delay Raw parameter value.

The Timer Delay Raw parameter value can range from 0 to 4095. So if the value is set to 100, for example, the timer delay will be 100 x 1 µs or 100 µs.

To set the delay for the timer:

- Use the Timer Selector to select Timer 1.
- Set the value of the Timer Delay Raw parameter.

You can set the Timer Selector and the Timer Delay Raw parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.TimerSelector.SetValue( TimerSelector_Timer1 );
Camera.TimerDelayRaw.SetValue( 100 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

##### Changing the Delay Time Base

By default, the Timer Delay Time Base is fixed at 1 µs (minimum value), and the timer delay is normally adjusted by setting the value of the Timer Delay Raw parameter. However, if you require a delay time that is longer than what you can achieve by changing the value of the Timer Delay Raw parameter alone, the Timer Delay Time Base Abs parameter can be used to change the delay time base.

The Timer Delay Time Base Abs parameter value sets the delay time base in µs. The default is 1 µs and it can be changed in 1 µs increments.

You can set the Timer Delay Time Base Abs parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter value:

```
Camera.TimerDelayTimebaseAbs.SetValue( 5 );
```

### Setting the Delay with an Absolute Value

You can also set the Timer duration by using an "absolute" value. This is accomplished by setting the Timer Duration Abs parameter. The units for setting this parameter are µs and the value can be set in increments of 1 µs.

To set the duration for the timer using an absolute value:

- Use the Timer Selector to select Timer 1.
- Set the value of the Timer Duration Abs parameter.

You can set the Timer Selector and the Timer Duration Abs parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.TimerSelector.SetValue( TimerSelector_Timer1 );
Camera.TimerDurationAbs.SetValue( 100 );
```

When you use the Timer Duration Abs parameter to set the duration time, the camera accomplishes the setting change by automatically changing the Timer Duration Raw parameter to achieve the value specified by the Timer Duration Abs setting. This leads to a limitation that you must keep in mind if you use Timer Duration Abs parameter to set the duration time. That is, you must set the Timer Duration Abs parameter to a value that is equivalent to a setting you could achieve by using the Timer Duration Raw and the current Timer Duration Base parameters. For example, if the time base was currently set to 50 µs, you could use the Timer Duration Abs parameter to set the duration to 50 µs, 100 µs, 150 µs, etc.

If you read the current value of the Timer Duration Abs parameter, the value will indicate the product of the Timer Duration Raw parameter and the Timer Duration Time Base. In other words, the Timer Duration Abs parameter will indicate the current duration time setting.

You should also be aware that if you change the duration time using the raw settings, the Timer Duration Abs parameter will automatically be updated to reflect the new duration time.

## 8.2.4.3 Setting a Timer Duration Time

There are two ways to set the duration time for the timer: by setting "raw" values or by setting an "absolute value". You can use whichever method you prefer to set the duration time.

### Setting the Duration with Raw Values

When the duration time for the timer is set using "raw" values, the duration time will be determined by a combination of two elements. The first element is the value of the Timer Duration Raw parameter, and the second element is the Timer Duration Time Base. The duration time is the product of these two elements:

Duration Time = (Timer Duration Raw Parameter Value) x (Timer Duration Time Base)

By default, the Timer Duration Time Base is fixed at 1 µs. Typically, the duration time is adjusted by setting only the Timer Duration Raw parameter value.

The Timer Duration Raw parameter value can range from 1 to 4095. So if the value is set to 100, for example, the timer duration will be 100 x 1 µs or 100 µs.

To set the duration for the timer:

- Use the Timer Selector to select the timer.
- Set the value of the Timer Duration Raw parameter.

You can set the Timer Selector and the Timer Duration Raw parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.TimerSelector.SetValue( TimerSelector_Timer1 );
Camera.TimerDurationRaw.SetValue( 100 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

#### Changing the Duration Time Base

By default, the Timer Duration Time Base is fixed at 1 µs, and the timer duration is normally adjusted by setting the value of the Timer Duration Raw parameter. However, if you require a duration time that is longer than what you can achieve by changing the value of the Timer Duration Raw parameter alone, the Timer Duration Time Base Abs parameter can be used to change the duration time base.

The Timer Duration Time Base Abs parameter value sets the duration time base in µs. The default is 1 µs and it can be changed in 1 µs increments.

You can set the Timer Duration Time Base Abs parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter value:

```
Camera.TimerDurationTimebaseAbs.SetValue( 5 );
```

### Setting the Duration with an Absolute Value

You can also set the Timer duration by using an "absolute" value. This is accomplished by setting the Timer Duration Abs parameter. The units for setting this parameter are µs and the value can be set in increments of 1 µs.

To set the duration for the timer using an absolute value:

- Use the Timer Selector to select the timer.
- Set the value of the Timer Duration Abs parameter.

You can set the Timer Selector and the Timer Duration Abs parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.TimerSelector.SetValue( TimerSelector_Timer1 );
Camera.TimerDurationAbs.SetValue( 100 );
```

When you use the Timer Duration Abs parameter to set the duration time, the camera accomplishes the setting change by automatically changing the Timer Duration Raw parameter to achieve the value specified by the Timer Duration Abs setting. This leads to a limitation that you must keep in mind if you use Timer Duration Abs parameter to set the duration time. That is, you must set the Timer Duration Abs parameter to a value that is equivalent to a setting you could achieve by using the Timer Duration Raw and the current Timer Duration Base parameters. For example, if the time base was currently set to 50 µs, you could use the Timer Duration Abs parameter to set the duration to 50 µs, 100 µs, 150 µs, etc.

If you read the current value of the Timer Duration Abs parameter, the value will indicate the product of the Timer Duration Raw parameter and the Timer Duration Time Base. In other words, the Timer Duration Abs parameter will indicate the current duration time setting.

You should also be aware that if you change the duration time using the raw settings, the Timer Duration Abs parameter will automatically be updated to reflect the new duration time.

# 8.3 Checking the State of the I/O Lines

## 8.3.1 Checking the State of the Output Line

You can determine the current state of the output line. To check the state of the line:

- Use the Line Selector parameter to select the output line.
- Read the value of the Line Status parameter to determine the current state of the selected line. A value of true means the line's state is currently high and a value of false means the line's state is currently low.

You can set the Line Selector and read the Line Status parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and read the parameter value:

```
// Select output line 1 and read the state
Camera.LineSelector.SetValue( LineSelector_Out1 );
bool outputLine1State = Camera.LineStatus.GetValue( );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

## 8.3.2 Checking the State of Both Lines

You can determine the current state of the input and output lines with a single operation. To check the state of both lines:

- Read the value of the Line Status All parameter.

You can read the Line Status All parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to read the parameter value:

```
int64_t lineState = Camera.LineStatusAll.GetValue( );
```

The Line Status All parameter is a 32 bit value. As shown in Figure 25, certain bits in the value are associated with each line, and the bits will indicate the state of the lines. If a bit is 0, it indicates that the state of the associated line is currently low. If a bit is 1, it indicates that the state of the associated line is currently high.

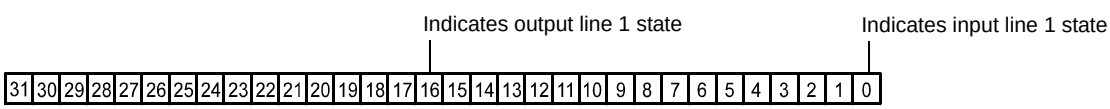



Fig. 25: Line Status All Parameter Bits

# 9 Image Acquisition Control

This section provides detailed information about controlling image acquisition. You will find details about choosing between image acquisition control modes, triggering image acquisition, setting the exposure time for each acquired image and about how the camera's maximum allowed acquisition frame rate can vary depending on the current camera settings.

## 9.1 Image Acquisition Control Modes: Legacy and Standard

Two different image acquisition control modes are available: the legacy mode and the standard mode. Previous Basler scout cameras with firmware version 3.2 and below only operate according to the legacy mode.

The legacy mode differs from the standard mode in only two respects:

- the acquisition start trigger of the standard mode is not available in the legacy mode.
- the frame start trigger of the standard mode is called "acquisition start trigger" in the legacy mode.

Recommendations for choosing the image acquisition control mode:

- If you want to operate the camera together with previous cameras we recommend choosing the legacy mode. In this mode, triggering the camera will be exactly as for previous cameras. Note also that you will not have to modify any code of your application.
- If you do not want to operate the camera together with previous cameras we most strongly recommend choosing the standard mode.

For more information about acquisition start trigger in the legacy mode, see Section 9.6 on page 109.

For more information about acquisition start trigger and frame start trigger in the standard mode, see Section 9.4 on page 91 and Section 9.5 on page 98, respectively.

For more information about determinig the camera's firmware version, see Section 11.13 on page 201.

When the camera is started for the first time after delivery from the factory the image acquisition control will be in legacy mode.

If you want the camera to start in standard mode, set the camera to standard mode (see below), save the current parameter settings as a user set and designate this user set as the startup set.

For more information about saving parameter settings as a user set and about working with user sets, see Section 11.14 on page 203.

### Setting the Image Acquisition Control Mode

You can set the image acquisition control mode from within your application software by using the pylon API. The following code snippets illustrate using the API to set the image acquisition control mode to standard mode and to legacy mode, respectively:

```
Camera.TriggerControlImplementation =
TriggerControlImplementation_Standard;
```

```
Camera.TriggerControlImplementation =
TriggerControlImplementation_Legacy;
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the image acquisition control mode.

For more information about the pylon Viewer, see Section 3.1 on page 25.

# 9.2 Means for Controlling Image Acquisition in Standard Mode

This section assumes that the standard mode is enabled for image acquisition control.

In principle, this section also applies if the legacy mode is enabled instead. In this case, however, the following differences must be taken into account:

- the acquisition start trigger of the standard mode is not available in the legacy mode.
- the frame start trigger of the standard mode is called "acquisition start trigger" in the legacy mode.

When the camera is started for the first time after delivery from the factory the image acquisition control will not be in standard mode but in legacy mode.

Use the legacy mode only if you want to operate the camera together with previous cameras not featuring the standard mode.

For more information about standard mode and legacy mode and how to set them, see Section 9.1 on page 83.

This section presents an overview of the elements involved with controlling the acquisition of images. Reading this section will give you an idea about how these elements fit together and will make it easier to understand the detailed information in the sections that follow.

Four major elements are involved in controlling the acquisition of images:

- Acquisition start and acquisition stop commands and the acquisition mode parameter
- The acquisition start trigger
- The frame start trigger
- Exposure time control

When reading the explanations in the overview and in this entire chapter, keep in mind that the term "frame" is typically used to mean a single acquired image.

When reading the material in this section, it is helpful to refer to Figure 26 on page 87 and to the use case diagrams in Section 9.8 on page 123. These diagrams present the material related to the acquisition start and stop commands, the acquisition mode, the acquisition start trigger, and the frame start trigger in a graphical format.

### Acquisition Start and Stop Commands and the Acquisition Mode

The Acquisition Start command prepares the camera to acquire frames. The camera cannot acquire frames unless an Acquisition Start command has first been executed.

A parameter called the Acquisition Mode has a direct bearing on how the Acquisition Start command operates.

If the Acquisition Mode parameter is set to "single frame", you can only acquire one frame after executing an Acquisition Start command. When one frame has been acquired, the Acquisition Start command will expire. Before attempting to acquire another frame, you must execute a new Acquisition Start command.

If the Acquisition Mode parameter is set to "continuous frame", an Acquisition Start command does not expire after a single frame is captured. Once an Acquisition Start command has been executed, you can acquire as many frames as you like. The Acquisition Start command will remain in effect until you execute an Acquisition Stop command. Once an Acquisition Stop command has been executed, the camera will not be able to acquire frames until a new Acquisition Start command is executed.

### Acquisition Start Trigger

The acquisition start trigger is essentially an enabler for the frame start trigger.

The acquisition start trigger has two modes of operation: off and on.

If the Trigger Mode parameter for the acquisition start trigger is set to off, the camera will generate all required acquisition start trigger signals internally, and you do not need to apply acquisition start trigger signals to the camera.

If the Trigger Mode parameter for the acquisition start trigger is set to on, the initial acquisition status of the camera will be "waiting for acquisition start trigger" (see Figure 26 on page 87). When the camera is in this acquisition status, it cannot react to frame start trigger signals. When an acquisition start trigger signal is applied to the camera, the camera will exit the "waiting for acquisition start trigger" acquisition status and enter a "waiting for frame start trigger" acquisition status. The camera can then react to frame start trigger signals. The camera will continue to react to frame start trigger signals until the number of frame start trigger signals it has received is equal to an integer parameter setting called the Acquisition Frame Count. At that point, the camera will return to the "waiting for acquisition start trigger" acquisition status and will remain in that status until a new acquisition start trigger signal is applied.

As an example, assume that the Trigger Mode parameter is set to on, the Acquisition Frame Count parameter is set to three, and the camera is in a "waiting for acquisition start trigger" acquisition status. When an acquisition start trigger signal is applied to the camera, it will exit the "waiting for acquisition start trigger" acquisition status and enter the "waiting for frame start trigger" acquisition status. Once the camera has received three frame start trigger signals, it will return to the "waiting for acquisition start trigger" acquisition status. At that point, you must apply a new acquisition start trigger signal to the camera to make it exit "waiting for acquisition start trigger".

### Frame Start Trigger

Assuming that an acquisition start trigger signal has just been applied to the camera, the camera will exit from the "waiting for acquisition start trigger" acquisition status and enter a "waiting for frame start trigger" acquisition status. Applying a frame start trigger signal to the camera at this point will exit the camera from the "waiting for frame start trigger" acquisition status and will begin the

process of exposing and reading out a frame (see Figure 26 on page 87). As soon as the camera is ready to accept another frame start trigger signal, it will return to the "waiting for frame start trigger" acquisition status. A new frame start trigger signal can then be applied to the camera to begin another frame exposure.

The frame start trigger has two modes: off and on.

If the Trigger Mode parameter for the frame start trigger is set to off, the camera will generate all required frame start trigger signals internally, and you do not need to apply frame start trigger signals to the camera. The rate at which the camera will generate the signals and acquire frames will be determined by the way that you set several frame rate related parameters.

If the Trigger Mode parameter for the frame start trigger is set to on, you must trigger frame start by applying frame start trigger signals to the camera. Each time a trigger signal is applied, the camera will begin a frame exposure. When frame start is being triggered in this manner, it is important that you do not attempt to trigger frames at a rate that is greater than the maximum allowed. (There is a detailed explanation about the maximum allowed frame rate at the end of this chapter.) Frame start trigger signals applied to the camera when it is not in a "waiting for frame start trigger" acquisition status will be ignored.

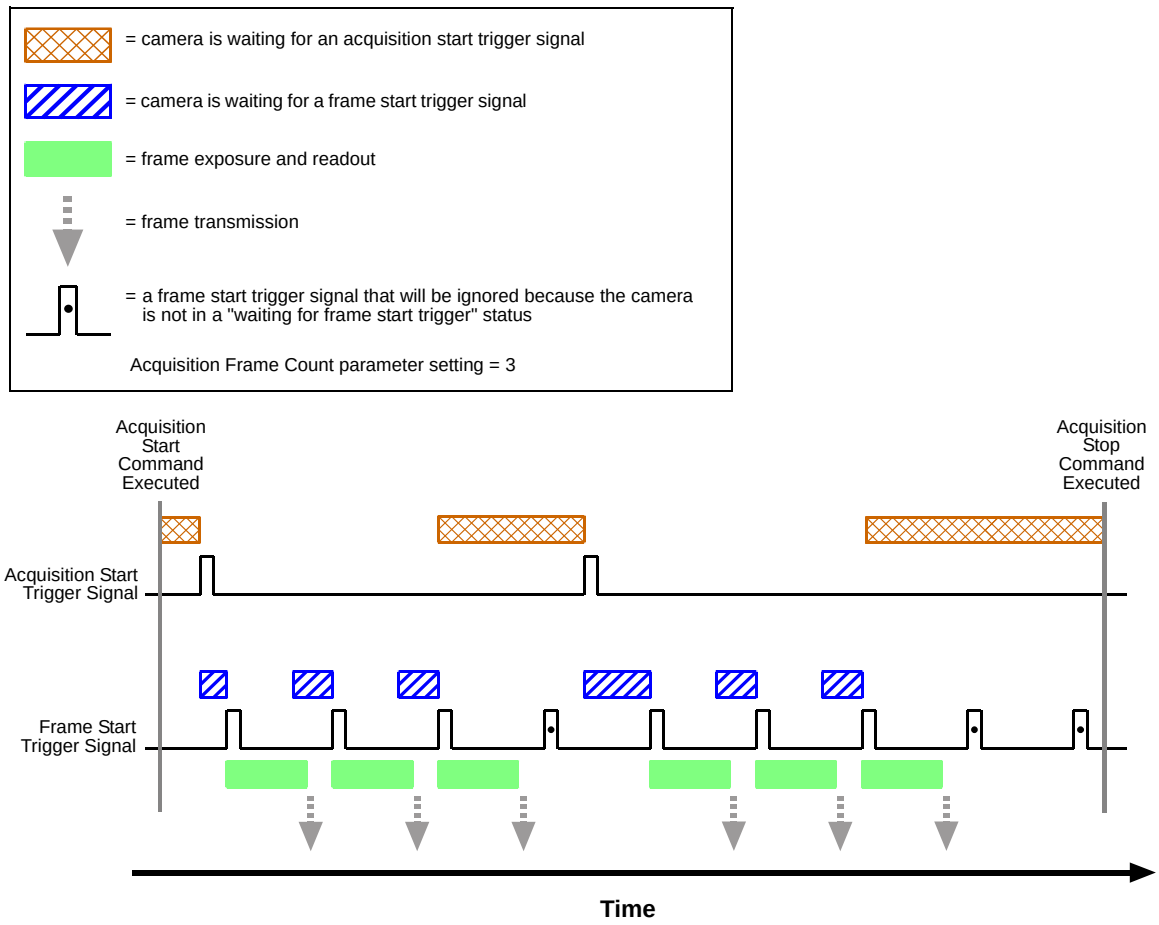

= camera is waiting for an acquisition start trigger signal
= camera is waiting for a frame start trigger signal
= frame exposure and readout
= frame transmission
= a frame start trigger signal that will be ignored because the camera is not in a "waiting for frame start trigger" status
Acquisition Frame Count parameter setting = 3
Acquisition Start Command Executed
Acquisition Stop Command Executed
Acquisition Start Trigger Signal
Frame Start Trigger Signal
Time

Fig. 26: Acquisition Start and Frame Start Triggering

### Applying Trigger Signals

The paragraphs above mention "applying a trigger signal". There are two ways to apply an acquisition start or a frame start trigger signal to the camera: via software or via hardware.

To apply trigger signals via software, you must first select the acquisition start or the frame start trigger and then indicate that software will be used as the source for the selected trigger signal. At that point, each time a Trigger Software command is executed, the selected trigger signal will be applied to the camera.

To apply trigger signals via hardware, you must first select the acquisition start or the frame start trigger and indicate that input line 1 will be used as the source for the selected trigger signal. At that point, each time a proper electrical signal is applied to input line 1, an occurance of the selected trigger signal will be recognized by the camera.

### The Trigger Selector

The concept of the "trigger selector" is very important to understand when working with the acquisition start and frame start triggers. Many of the parameter settings and the commands that apply to the triggers have names that are not specific to a particular type of trigger, for example, the acquisition start trigger has a mode setting and the frame start trigger has a mode setting. But in Basler pylon there is a single parameter, the Trigger Mode parameter, that is used to set the mode for both of these triggers. Also, the Trigger Software command mentioned earlier can be executed for either the acquisition start trigger or the frame start trigger. So if you want to set the Trigger Mode or execute a Trigger Software command for the acquisition start trigger rather than the frame start trigger, how do you do it? The answer is, by using the Trigger Selector parameter. Whenever you want to work with a specific type of trigger, your first step is to set the Trigger Selector parameter to the trigger you want to work with (either the acquisition start trigger or the frame start trigger). At that point, the changes you make to the Trigger Mode, Trigger Source, etc., will be applied to the selected trigger only.

### Exposure Time Control

As mentioned earlier, when a frame start trigger signal is applied to the camera, the camera will begin to acquire a frame. A critical aspect of frame acquisition is how long the pixels in the camera’s sensor will be exposed to light during the frame acquisition.

If the camera is set for software frame start triggering, the exposure time parameters will determine the exposure time for each frame.

If the camera is set for hardware frame start triggering, there are two modes of operation: "timed" and "trigger width". With the "timed" mode, the exposure time parameters will determine the exposure time for each frame. With the "trigger width" mode, the way that you manipulate the rise and fall of the hardware signal will determine the exposure time. The "trigger width" mode is especially useful if you want to change the exposure time from frame to frame.

# 9.3 Acquisition Start and Stop Commands and the Acquisition Mode (Legacy and Standard Mode)

Executing an Acquisition Start commmand prepares the camera to acquire frames. You must execute an Acquisition Start command before you can begin acquiring frames.

Executing an Acquisition Stop command terminates the camera's ability to acquire frames. When the camera receives an Acquisition stop command:

- If the camera is not in the process of acquiring a frame, its ability to acquire frames will be terminated immediately.
- If the camera is in the process of acquiring a frame, the frame acquisition process will be allowed to finish and the camera's ability to acquire new frames will be terminated.

The camera's Acquisition Mode parameter has two settings: single frame and continuous. The use of Acquisition Start and Acquisition Stop commands and the camera's Acquisition Mode parameter setting are related.

If the camera's Acquisition Mode parameter is set for single frame, after an Acquisition Start command has been executed, a single frame can be acquired. When acquisition of one frame is complete, the camera will execute an Acquisition Stop command internally and will no longer be able to acquire frames. To acquire another frame, you must execute a new Acquisition Start command.

If the camera's Acquisition Mode parameter is set for continuous frame, after an Acquisition Start command has been executed, frame acquisition can be triggered as desired. Each time a frame trigger is applied while the camera is in a "waiting for frame trigger" acquisition status, the camera will acquire and transmit a frame. The camera will retain the ability to acquire frames until an Acquisition Stop command is executed. Once the Acquisition Stop command is received, the camera will no longer be able to acquire frames.

### Setting the Acquisition Mode and Issuing Start/Stop Commands

You can set the Acquisition Mode parameter value and you can execute Acquisition Start or Acquisition Stop commands from within your application software by using the Basler pylon API. The code snippet below illustrates using the API to set the Acquisition Mode parameter value and to execute an Acquisition Start command. Note that the snippet also illustrates setting several parameters regarding frame triggering. These parameters are discussed later in this chapter.

```
Camera.AcquisitionMode.SetValue( AcquisitionMode_SingleFrame );
Camera.TriggerSelector.SetValue( TriggerSelector_FrameStart );
Camera.TriggerMode.SetValue( TriggerMode_On );
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
Camera.ExposureMode.SetValue( ExposureMode_Timed );
Camera.ExposureTimeAbs.SetValue( 3000 );
```

```
Camera.AcquisitionStart.Execute( );
```

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

When the camera's acquisition mode is set to single frame, the maximum possible acquisition frame rate for a given AOI cannot be achieved. This is true because the camera performs a complete internal setup cycle for each single frame and because it cannot be operated with "overlapped" exposure.

To achieve the maximum possible acquisition frame rate set the camera for the continuous acquisition mode and also use "overlapped" exposure.

For more information about overlapped exposure, see Section 9.9 on page 133.

# 9.4 The Acquisition Start Trigger in Standard Mode

This section only applies if the standard mode is enabled for image acquisition control.

When the camera is started for the first time after delivery from the factory the image acquisition control will not be in standard mode but in legacy mode.

Use the legacy mode only if you want to operate the camera together with previous cameras not featuring the standard mode.

For more information about standard mode and legacy mode and how to set them, see Section 9.1 on page 83.

The acquisition start trigger is used in conjunction with the frame start trigger to control the acquisition of frames. In essence, the acquisition start trigger is used as an enabler for the frame start trigger. Acquisition start trigger signals can be generated within the camera or may be applied externally as software or hardware acquisition start trigger signals.

When the acquisition start trigger is enabled, the camera’s initial acquisition status is "waiting for acquisition start trigger". When the camera is in this acquisition status, it will ignore any frame start trigger signals it receives. If an acquisition start trigger signal is applied to the camera, it will exit the "waiting for acquisition start trigger" acquisition status and enter the "waiting for frame start trigger" acquisition status. In this acquisition status, the camera can react to frame start trigger signals and will begin to expose a frame each time a proper frame start trigger signal is applied.

A primary feature of the acquisition start trigger is that after an acquisition start trigger signal has been applied to the camera and the camera has entered the "waiting for frame start trigger" acquisition status, the camera will return to the "waiting for acquisition start trigger" acquisition status once a specified number of frame start triggers has been received. Before more frames can be acquired, a new acquisition start trigger signal must be applied to the camera to exit it from "waiting for acquisition start trigger" status. Note that this feature only applies when the Trigger Mode parameter for the acquisition start trigger is set to on. This feature is explained in greater detail in the following sections.

## 9.4.1 Acquisition Start Trigger Mode (Standard Mode)

The main parameter associated with the acquisition start trigger is the Trigger Mode parameter. The Trigger Mode parameter for the acquisition start trigger has two available settings: off and on.

### 9.4.1.1 Acquisition Start Trigger Mode = Off

When the Trigger Mode parameter for the acquisition start trigger is set to off, the camera will generate all required acquisition start trigger signals internally, and you do not need to apply acquisition start trigger signals to the camera.

### 9.4.1.2 Acquisition Start Trigger Mode = On

When the Trigger Mode parameter for the acquisition start trigger is set to on, the camera will initially be in a "waiting for acquisition start trigger" acquisition status and cannot react to frame start trigger signals. You must apply an acquisition start trigger signal to the camera to exit the camera from the "waiting for acquisition start trigger" acquisition status and enter the "waiting for frame start trigger" acquisition status. The camera can then react to frame start trigger signals and will continue to do so until the number of frame start trigger signals it has received is equal to the current Acquisition Frame Count parameter setting. The camera will then return to the "waiting for acquisition start trigger" acquisition status. In order to acquire more frames, you must apply a new acquisition start trigger signal to the camera to exit it from the "waiting for acquisition start trigger" acquisition status.

When the Trigger Mode parameter for the acquisition start trigger is set to on, you must select a source signal to serve as the acquisition start trigger. The Trigger Source parameter specifies the source signal. The available selections for the Trigger Source parameter are:

- Software - When the source signal is set to software, you apply an acquisition start trigger signal to the camera by executing an Trigger Software command for the acquisition start trigger on the host PC.
- Line 1 - When the source signal is set to line 1, you apply an acquisition start trigger signal to the camera by injecting an externally generated electrical signal (commonly referred to as a hardware trigger signal) into physical input line 1 on the camera.

If the Trigger Source parameter for the acquisition start trigger is set to Line 1, you must also set the Trigger Activation parameter. The available settings for the Trigger Activation parameter are:

- Rising Edge - specifies that a rising edge of the electrical signal will act as the acquisition start trigger.
- Falling Edge - specifies that a falling edge of the electrical signal will act as the acquisition start trigger.

**When the Trigger Mode parameter for the acquisition start trigger is set to on, the camera's Acquisition Mode parameter must be set to continuous.**

## 9.4.2 Acquisition Frame Count (Standard Mode)

When the Trigger Mode parameter for the acquisition start trigger is set to on, you must set the value of the camera's Acquisition Frame Count parameter. The value of the Acquisition Frame Count can range from 1 to 255.

With acquisition start triggering on, the camera will initially be in a "waiting for acquisition start trigger" acquisition status. When in this acquisition status, the camera cannot react to frame start trigger signals. If an acquisition start trigger signal is applied to the camera, the camera will exit the "waiting for acquisition start trigger" acquisition status and will enter the "waiting for frame start trigger" acquisition status. It can then react to frame start trigger signals. When the camera has received a number of frame start trigger signals equal to the current Acquisition Frame Count parameter setting, it will return to the "waiting for acquisition start trigger" acquisition status. At that point, you must apply a new acquisition start trigger signal to exit the camera from the "waiting for acquisition start trigger" acquisition status.

For more information about the pylon Viewer, see Section 3.1 on page 25.

### 9.4.3 Setting the Acquisition Start Trigger Mode and Related Parameters (Standard Mode)

You can set the Trigger Mode and Trigger Source parameters for the acquisition start trigger and also set the Acquisition Frame Count parameter value from within your application software by using the Basler pylon API.

The following code snippet illustrates using the API to set the Trigger Mode to on, the Trigger Source to software, and the Acquisition Frame Count to 5:

```
// Set the acquisition mode to continuous(the acquisition mode must
// be set to continuous when acquisition start triggering is on)
Camera.AcquisitionMode.SetValue( AcquisitionMode_Continuous );

// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Software );
// Set the acquisition frame count
Camera.AcquisitionFrameCount.SetValue( 5 );
```

The following code snippet illustrates using the API to set the Trigger Mode to on, the Trigger Source to line 1, the Trigger Activation to rising edge, and the Acquisition Frame Count to 5:

```
// Set the acquisition mode to continuous(the acquisition mode must
// be set to continuous when acquisition start triggering is on)
Camera.AcquisitionMode.SetValue( AcquisitionMode_Continuous );

// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
// Set the activation mode for the selected trigger to rising edge
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
// Set the acquisition frame count
Camera.AcquisitionFrameCount.SetValue( 5 );
```

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

## 9.4.4 Using a Software Acquisition Start Trigger (Standard Mode)

### 9.4.4.1 Introduction

If the camera's Acquisition Start Trigger Mode parameter is set to on and the Acquisition Start Trigger Source parameter is set to software, you must apply a software acquisition start trigger signal to the camera before you can begin frame acquisition.

A software acquisition start trigger signal is applied by:

- Setting the Trigger Selector parameter to Acquisition Start.
- Executing a Trigger Software command.

The camera will initially be in a "waiting for acquisition start trigger" acquisition status. It cannot react to frame trigger signals when in this acquisition status. When a software acquisition start trigger signal is received by the camera, it will exit the "waiting for acquisition start trigger" acquisition status and will enter the "waiting for frame start trigger" acquisition status. It can then react to frame start trigger signals. When the number of frame start trigger signals received by the camera is equal to the current Acquisition Frame Count parameter setting, the camera will return to the "waiting for acquisition start trigger" acquisition status. When a new software acquisition start trigger signal is applied to the camera, it will again exit from the "waiting for acquisition start trigger" acquisition status and enter the "waiting for frame start trigger" acquisition status.

(Note that as long as the Trigger Selector parameter is set to Acquisition Start, a software acquisition start trigger will be applied to the camera each time a Trigger Software command is executed.)

### 9.4.4.2 Setting the Parameters Related to Software Acquisition Start Triggering and Applying a Software Trigger Signal

You can set all of the parameters needed to perform software acquisition start triggering from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the parameter values and to execute the commands related to software acquisition start triggering with the camera set for continuous frame acquisition mode:

```
// Set the acquisition mode to continuous(the acquisition mode must
// be set to continuous when acquisition start triggering is on)
Camera.AcquisitionMode.SetValue( AcquisitionMode_Continuous );

// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Software );
// Set the acquisition frame count
```

```
Camera.AcquisitionFrameCount.SetValue( 5 );
// Execute an acquisition start command to prepare for frame acquisition
     Camera.AcquisitionStart.Execute( );
     while ( ! finished )
     {
         // Execute a trigger software command to apply a software acquisition
         // start trigger signal to the camera
         Camera.TriggerSoftware.Execute( );

         // Perform the required functions to parameterize the frame start
         // trigger, to trigger 5 frame starts, and to retrieve 5 frames here
     }
     Camera.AcquisitionStop.Execute( );

// Note: as long as the Trigger Selector is set to Acquisition Start, executing
// a Trigger Software command will apply a software acquisition start trigger
// signal to the camera
```

You can also use the Basler pylon Viewer application to easily set the parameters.

## 9.4.5 Using a Hardware Acquisition Start Trigger (Standard Mode)

### 9.4.5.1 Introduction

If the Trigger Mode parameter for the acquisition start trigger is set to on and the Trigger Source parameter is set to line 1, an externally generated electrical signal injected into physical input line 1 on the camera will act as the acquisition start trigger signal for the camera. This type of trigger signal is generally referred to as a hardware trigger signal or as an external acquisition start trigger signal (ExASTrig).

A rising edge or a falling edge of the ExASTrig signal can be used to trigger acquisition start. The Trigger Activation parameter is used to select rising edge or falling edge triggering.

When the Trigger Mode parameter is set to on, the camera will initially be in a "waiting for acquisition start trigger" acquisition status. It cannot react to frame start trigger signals when in this acquisition status. When the appropriate ExASTrig signal is applied to line 1 (e.g, a rising edge of the signal for rising edge triggering), the camera will exit the "waiting for acquisition start trigger" acquisition status and will enter the "waiting for frame start trigger" acquisition status. It can then react to frame start trigger signals. When the number of frame start trigger signals received by the camera is equal to the current Acquisition Frame Count parameter setting, the camera will return to the "waiting for acquisition start trigger" acquisition status. When a new ExASTrig signal is applied to line 1, the camera will again exit from the "waiting for acquisition start trigger" acquisition status and enter the "waiting for frame start trigger" acquisition status.

For more information about setting the camera for hardware acquisition start triggering and selecting the input line to receive the ExASTrig signal, see Section 9.4.5.2 on page 97.

For more information about the electrical requirements for input line 1, see Section 7.7.1 on page 64.

### 9.4.5.2 Setting the Parameters Related to Hardware Acquisition Start Triggering and Applying a Hardware Trigger Signal

You can set all of the parameters needed to perform hardware acquisition start triggering from within your application by using the Basler pylon API. The following code snippet illustrates using the API to set the parameter values required to enable rising edge hardware acquisition start triggering with line 1 as the trigger source:

```
// Set the acquisition mode to continuous(the acquisition mode must
// be set to continuous when acquisition start triggering is on)
Camera.AcquisitionMode.SetValue( AcquisitionMode_Continuous );

// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
// Set the activation mode for the selected trigger to rising edge
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
// Set the acquisition frame count
Camera.AcquisitionFrameCount.SetValue( 5 );
// Execute an acquisition start command to prepare for frame acquisition
Camera.AcquisitionStart.Execute( );
     while ( ! finished )
     {
         // Apply a rising edge of the externally generated electrical signal
         // (ExASTrig signal) to input line 1 on the camera

              // Perform the required functions to parameterize the frame start
              // trigger, to trigger 5 frame starts, and to retrieve 5 frames here
     }
     Camera.AcquisitionStop.Execute( );
```

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

# 9.5 The Frame Start Trigger in Standard Mode

This section only applies if the standard mode is enabled for image acquisition control.

When the camera is started for the first time after delivery from the factory the image acquisition control will not be in standard mode but in legacy mode.

Use the legacy mode only if you want to operate the camera together with previous cameras not featuring the standard mode.

For more information about standard mode and legacy mode and how to set them, see Section 9.1 on page 83.

The frame start trigger is used to begin frame acquisition. Assuming that the camera is in a "waiting for frame start trigger" acquisition status, it will begin a frame acquisition each time it receives a frame start trigger signal.

Note that in order for the camera to be in a "waiting for frame start trigger" acquisition status:

- The Acquisition Mode parameter must be set correctly.
- A proper Acquisition Start command must be applied to the camera.
- A proper acquisition start trigger signal must be applied to the camera (if the Trigger Mode parameter for the acquisition start trigger is set to on).

For more information about the Acquisition Mode parameter and about Acquisition Start and Acquisition Stop commands, see Section 9.2 on page 85 and Section 9.3 on page 89.

For more information about the acquisition start trigger, and about the acquisition status, see Section 9.2 on page 85 and Section 9.4 on page 91.

Referring to the use case diagrams that appear in Section 9.8 on page 123 can help you understand the explanations of the frame start trigger.

## 9.5.1 Frame Start Trigger Mode (Standard Mode)

The main parameter associated with the frame start trigger is the Trigger Mode parameter. The Trigger Mode parameter for the frame start trigger has two available settings: off and on.

### 9.5.1.1 Frame Start Trigger Mode = Off

When the Frame Start Trigger Mode parameter is set to off, the camera will generate all required frame start trigger signals internally, and you do not need to apply frame start trigger signals to the camera.

With the trigger mode set to off, the way that the camera will operate the frame start trigger depends on the setting of the camera's Acquisition Mode parameter:

- If the Acquisition Mode parameter is set to single frame, the camera will automatically generate a single frame start trigger signal whenever it receives an Acquisition Start command.
- If the Acquisition Mode parameter is set to continuous frame, the camera will automatically begin generating frame start trigger signals when it receives an Acquisition Start command. The camera will continue to generate frame start trigger signals until it receives an Acquisition Stop command.

  The rate at which the frame start trigger signals are generated may be determined by the camera's Acquisition Frame Rate Abs parameter:

  - If the parameter is not enabled, the camera will generate frame start trigger signals at the maximum rate allowed with the current camera settings.
  - If the parameter is enabled and is set to a value less than the maximum allowed frame rate with the current camera settings, the camera will generate frame start trigger signals at the rate specified by the parameter setting.
  - If the parameter is enabled and is set to a value greater than the maximum allowed frame rate with the current camera settings, the camera will generate frame start trigger signals at the maximum allowed frame rate.

For information about setting the Acquisition Frame Rate Abs parameter, see Section 9.5.1.3 on page 101.

Keep in mind that the camera will only react to frame start triggers when it is in a "waiting for frame start trigger" acquisition status. For more information about the acquisition status, see Section 9.2 on page 85 and Section 9.4 on page 91.

### Exposure Time Control with the Frame Start Trigger Off

When the Trigger Mode parameter for the frame start trigger is set to off, the exposure time for each frame acquisition is determined by the value of the camera's Exposure Time Abs parameter.

For more information about the camera's Exposure Time Abs parameter, see Section 9.7 on page 121.

## 9.5.1.2 Frame Start Trigger Mode = On

When the Trigger Mode parameter for the frame start trigger is set to on, you must apply a frame start trigger signal to the camera each time you want to begin a frame acquisition. The Trigger Source parameter specifies the source signal that will act as the frame start trigger signal. The available selections for the Trigger Source parameter are:

- Software - When the source signal is set to software, you apply a frame start trigger signal to the camera by executing a Trigger Software command for the frame start trigger on the host PC.
- Line 1 - When the source signal is set to line 1, you apply a frame start trigger signal to the camera by injecting an externally generated electrical signal (commonly referred to as a hardware trigger signal) into physical input line 1 on the camera.

If the Trigger Source parameter is set to Line 1, you must also set the Trigger Activation parameter. The available settings for the Trigger Activation parameter are:

- Rising Edge - specifies that a rising edge of the electrical signal will act as the frame start trigger.
- Falling Edge - specifies that a falling edge of the electrical signal will act as the frame start trigger.

For more information about using a software trigger to control frame acquisition start, see Section 9.4.4 on page 95.

For more information about using a hardware trigger to control frame acquisition start, see Section 9.4.5 on page 96.

By default, input line 1 is selected as the source signal for the frame start trigger.

Keep in mind that the camera will only react to frame start triggers when it is in a "waiting for frame start trigger" acquisition status. For more information about the acquisition status, see Section 9.2 on page 85 and Section 9.4 on page 91.

### Exposure Time Control with the Frame Start Trigger On

When the Trigger Mode parameter for the frame start trigger is set to on and the Trigger Source parameter is set to software, the exposure time for each frame acquisition is determined by the camera's exposure time parameters.

When the Trigger Mode parameter is set to on and the Trigger Source parameter is set to input line 1, the exposure time for each frame acquisition can be controlled with the exposure time parameters or it can be controlled by manipulating the hardware trigger signal.

For more information about controlling exposure time when using a software trigger, see Section 9.4.4 on page 95.

For more information about controlling exposure time when using a hardware trigger, see Section 9.4.5 on page 96.

For more information about exposure time parameters, see Section 9.7 on page 121.

## 9.5.1.3 Setting the Frame Start Trigger Mode and Related Parameters

You can set the Trigger Mode and related parameter values for the frame start trigger from within your application software by using the Basler pylon API. If your settings make it necessary, you can also set the Trigger Source parameter.

The following code snippet illustrates using the API to set the Trigger Mode for the frame start trigger to on and the Trigger Source to input line 1:

```
// Select the frame start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_FrameStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
```

The following code snippet illustrates using the API to set the Acquisition Mode to continuous, the Trigger Mode to off, and the Acquisition Frame Rate to 60:

```
// Set the acquisition mode to continuous frame
Camera.AcquisitionMode.SetValue( AcquisitionMode_Continuous );
// Select the frame start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_FrameStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_Off );
// Set the exposure time
Camera.ExposureTimeAbs.SetValue( 3000 );
// Enable the acquisition frame rate parameter and set the frame rate. (Enabling
// the acquisition frame rate parameter allows the camera to control the frame
// rate internally.)
Camera.AcquisitionFrameRateEnable.SetValue( true );
Camera.AcquisitionFrameRateAbs.SetValue( 60.0 );
// Start frame capture
```

```
Camera.AcquisitionStart.Execute( );
```

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

## 9.5.2 Using a Software Frame Start Trigger (Standard Mode)

### 9.5.2.1 Introduction

If the Trigger Mode parameter for the frame start trigger is set to on and the Trigger Source parameter is set to software, you must apply a software frame start trigger signal to the camera to begin each frame acquisition. Assuming that the camera is in a "waiting for frame start trigger" acquisition status, frame exposure will start when the software frame start trigger signal is received by the camera. Figure 27 illustrates frame acquisition with a software frame start trigger signal.

When the camera receives a software trigger signal and begins exposure, it will exit the "waiting for frame start trigger" acquisition status because at that point, it cannot react to a new frame start trigger signal. As soon as the camera is capable of reacting to a new frame start trigger signal, it will automatically return to the "waiting for frame start trigger" acquisition status.

When you are using a software trigger signal to start each frame acquisition, the camera's Exposure Mode parameter must be set to timed. The exposure time for each acquired frame will be determined by the value of the camera's exposure time parameters.

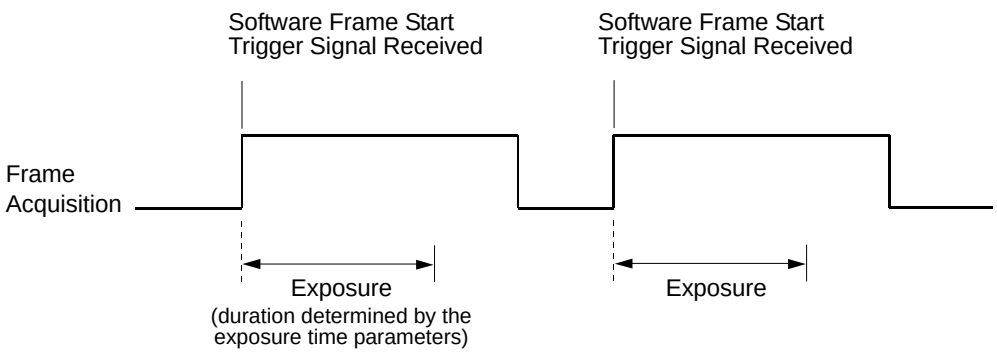



Fig. 27: Frame Acquisition with a Software Frame Start Trigger

When you are using a software trigger signal to start each frame acquisition, the frame rate will be determined by how often you apply a software trigger signal to the camera, and you should not attempt to trigger frame acquisition at a rate that exceeds the maximum allowed for the current camera settings. (There is a detailed explanation about the maximum allowed frame rate at the end of this chapter.) Software frame start trigger signals that are applied to the camera when it is not ready to receive them will be ignored.

Section 9.5.2.2 on page 103 includes more detailed information about applying a software frame start trigger to the camera using Basler pylon.

For more information about exposure time parameters, see Section 9.7 on page 121.

For more information about determining the maximum allowed frame rate, see Section 9.12 on page 144.

### 9.5.2.2 Setting the Parameters Related to Software Frame Start Triggering and Applying a Software Trigger Signal

You can set all of the parameters needed to perform software frame start triggering from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the parameter values and to execute the commands related to software frame start triggering with the camera set for continuous frame acquisition mode. In this example, the trigger mode for the acquisition start trigger will be set to off:

```
// Set the acquisition mode to continuous frame
Camera.AcquisitionMode.SetValue( AcquisitionMode_Continuous );
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_Off );
// Disable the acquisition frame rate parameter (this will disable the camera's
// internal frame rate control and allow you to control the frame rate with
// software frame start trigger signals within the limits imposed by other
// parameter settings).
Camera.AcquisitionFrameRateEnable.SetValue( false );
// Select the frame start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_FrameStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Software );
// Set for the timed exposure mode
Camera.ExposureMode.SetValue( ExposureMode_Timed );
// Set the exposure time
Camera.ExposureTimeAbs.SetValue( 3000 );
// Execute an acquisition start command to prepare for frame acquisition
Camera.AcquisitionStart.Execute( );
while ( ! finished )
{
// Execute a Trigger Software command to apply a frame start
// trigger signal to the camera
Camera.TriggerSoftware.Execute( );
// Retrieve acquired frame here
}
     Camera.AcquisitionStop.Execute( );
```

```
// Note: as long as the Trigger Selector is set to FrameStart, executing
// a Trigger Software command will apply a software frame start trigger
// signal to the camera
```

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

## 9.5.3 Using a Hardware Frame Start Trigger (Standard Mode)

### 9.5.3.1 Introduction

If the Trigger Mode parameter for the frame start trigger is set to on and the Trigger Source parameter is set to input line 1, an externally generated electrical signal applied to input line 1 on the camera will act as the frame start trigger signal for the camera. This type of trigger signal is generally referred to as a hardware trigger signal or as an external frame start trigger signal (ExFSTrig).

A rising edge or a falling edge of the ExFSTrig signal can be used to trigger frame acquisition. The Trigger Activation parameter is used to select rising edge or falling edge triggering.

Assuming that the camera is in a "waiting for frame start trigger" acquisition status, frame acquisition will start whenever the appropriate edge transition is received by the camera.

When the camera receives a hardware trigger signal and begins exposure, it will exit the "waiting for frame start trigger" acquisition status because at that point, it cannot react to a new frame start trigger signal. As soon as the camera is capable of reacting to a new frame start trigger signal, it will automatically return to the "waiting for frame start trigger" acquisition status.

When the camera is operating under control of an ExFSTrig signal, the period of the ExFSTrig signal will determine the rate at which the camera is acquiring frames:

$$\frac{1}{\text{ExFSTrig period in seconds}} = \text{Frame Rate}$$

For example, if you are operating a camera with an ExFSTrig signal period of 20 ms (0.020 s):

$$\frac{1}{0.020} = 50 \text{ fps}$$

So in this case, the frame rate is 50 fps.

| | |
|---|---|
| | If you are triggering frame acquisition with an ExFSTrig signal and you attempt to acquire frames at too high a rate, some of the frame trigger signals that you apply will be received by the camera when it is not in a "waiting for frame start trigger" acquisition status. The camera will ignore any frame start trigger signals that it receives when it is not "waiting for frame start trigger". This situation is commonly referred to as "over triggering" the camera.<br><br>To avoid over triggering, you should not attempt to acquire frames at a rate that exceeds the maximum allowed with the current camera settings. |

For more information about setting the camera for hardware acquisition start triggering and selecting the input line to receive the ExFSTrig signal, see Section 9.4.5.2 on page 97.

For more information about the electrical requirements for input line 1, see Section 7.7.1 on page 64.

For more information about determining the maximum allowed frame rate, see Section 9.12 on page 144.

### 9.5.3.2 Exposure Modes

If you are triggering the start of frame acquisition with an externally generated frame start trigger (ExFSTrig) signal, two exposure modes are available: timed and trigger width.

#### Timed Exposure Mode

When timed mode is selected, the exposure time for each frame acquisition is determined by the the camera's exposure time parameters. If the camera is set for rising edge triggering, the exposure time starts when the ExFSTrig signal rises. If the camera is set for falling edge triggering, the exposure time starts when the ExFSTrig signal falls. The following figure illustrates timed exposure with the camera set for rising edge triggering.

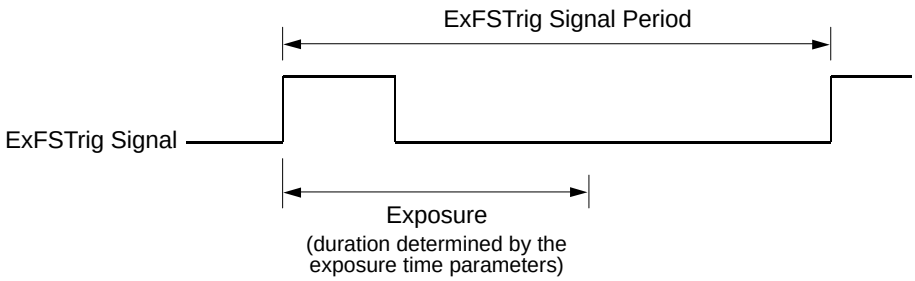



Fig. 28: Timed Exposure with Rising Edge Triggering

Note that if you attempt to trigger a new exposure start while the previous exposure is still in progress, the trigger signal will be ignored.

This situation is illustrated below for rising edge triggering.

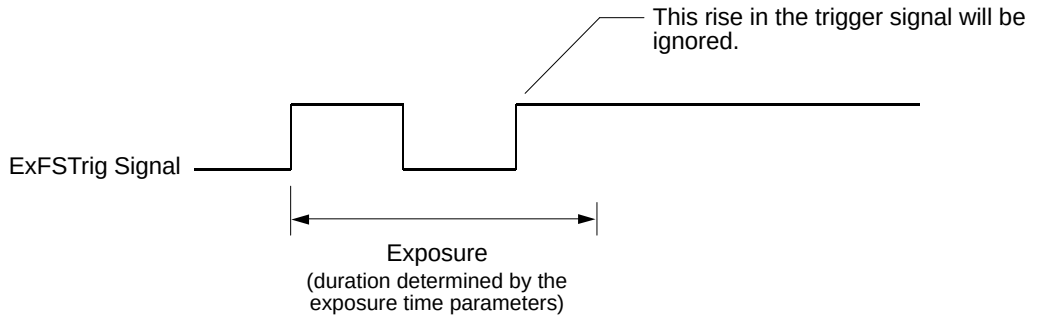

This rise in the trigger signal will be ignored.
ExFSTrig Signal
Exposure
(duration determined by the exposure time parameters)

Fig. 29: Overtriggering with Timed Exposure

For more information about the camera's exposure time parameters, see Section 9.7 on page 121.

## Trigger Width Exposure Mode

When trigger width exposure mode is selected, the length of the exposure for each frame acquisition will be directly controlled by the ExFSTrig signal. If the camera is set for rising edge triggering, the exposure time begins when the ExFSTrig signal rises and continues until the ExFSTrig signal falls. If the camera is set for falling edge triggering, the exposure time begins when the ExFSTrig signal falls and continues until the ExFSTrig signal rises. Figure 30 illustrates trigger width exposure with the camera set for rising edge triggering.

Trigger width exposure is especially useful if you intend to vary the length of the exposure time for each captured frame.

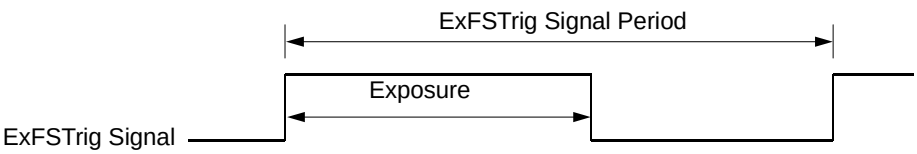



Fig. 30: Trigger Width Exposure with Rising Edge Triggering

When you operate the camera in trigger width exposure mode, you must also use the camera's exposure time prameters to set an exposure time. This parameter setting will be used by the camera to operate the Trigger Ready signal.

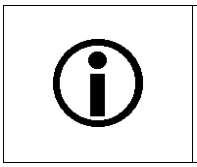
You should adjust the exposure setting to represent the shortest exposure time you intend to use. For example, assume that you will be using trigger width exposure mode and that you intend to use the ExFSTrig signal to vary the exposure time in a range from 3000 µs to 5500 µs. In this case you would use the exposure setting to set the exposure time to 3000 µs.

For more information about the Trigger Ready signal, see Section 9.10.3 on page 136.

For more information about the camera's exposure time parameters, see Section 9.7 on page 121.

### 9.5.3.3 Frame Start Trigger Delay

The trigger delay feature lets you specify a delay (in microseconds) that will be applied between the receipt of a hardware frame start trigger and when the trigger will become effective.



The trigger delay will not operate if the Trigger Mode parameter for frame start is set to off or if you are using a software frame start trigger.

For more information about the trigger delay feature and how to use it, see Section 11.10 on page 193.

### 9.5.3.4 Setting the Parameters Related to Hardware Frame Start Triggering and Applying a Hardware Trigger Signal

You can set all of the parameters needed to perform hardware frame start triggering from within your application by using the Basler pylon API. The following code snippet illustrates using the API to set the camera for single frame acquisition mode with the trigger mode for the acquisition start trigger set to off. We will use the timed exposure mode with input line 1 as the trigger source and with rising edge triggering. In this example, we will use a trigger delay:

```
// Set the acquisition mode to single frame
Camera.AcquisitionMode.SetValue( AcquisitionMode_SingleFrame );
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_Off );
// Select the frame start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_FrameStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
// Set the trigger activation mode to rising edge
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
// Set the trigger delay for one millisecond (1000us == 1ms == 0.001s)
double TriggerDelay_us = 1000.0;
Camera.TriggerDelayAbs.SetValue( TriggerDelay_us );
// Set for the timed exposure mode
Camera.ExposureMode.SetValue( ExposureMode_Timed );
// Set the exposure time
Camera.ExposureTimeAbs.SetValue( 3000 );
// Execute an acquisition start command to prepare for frame acquisition
```

```
Camera.AcquisitionStart.Execute( );

// Frame acquisition will start when the externally generated
// frame start trigger signal (ExFSTrig signal)goes high
```

The following code snippet illustrates using the API to set the parameter values and execute the commands related to hardware frame start triggering with the camera set for continuous frame acquisition mode and the trigger mode for the acquisition start trigger set to off. We will use the trigger width exposure mode with input line 1 as the trigger source and with rising edge triggering:

```
// Set the acquisition mode to continuous frame
Camera.AcquisitionMode.SetValue( AcquisitionMode_Continuous );
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_Off );
// Disable the acquisition frame rate parameter (this will disable the camera's
// internal frame rate control and allow you to control the frame rate with
// external frame start trigger signals)
Camera.AcquisitionFrameRateEnable.SetValue( false );
// Select the frame start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_FrameStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
// Set the trigger activation mode to rising edge
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
// Set for the trigger width exposure mode
Camera.ExposureMode.SetValue( ExposureMode_TriggerWidth );
// Set the shortest exposure time -
// the shortest exposure time we plan to use is 1500 us
Camera.ExposureTimeAbs.SetValue( 1500 );
// Prepare for frame acquisition here
     Camera.AcquisitionStart.Execute( );
     while ( ! finished )
     {
         // Frame acquisition will start each time the externally generated
         // frame start trigger signal (ExFSTrig signal)goes high

         // Retrieve the captured frames
     }
     Camera.AcquisitionStop.Execute( );
```

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

# 9.6 The Acquisition Start Trigger in Legacy Mode

This section only applies if the legacy mode is enabled for image acquisition control.

Use the legacy mode only if you want to operate the camera together with previous cameras not featuring the standard mode. Otherwise, we most strongly recommend enabling the standard mode.

When the camera is started for the first time after delivery from the factory the image acquisition control will be in legacy mode.

The acquisition start trigger of the legacy mode is called "frame start trigger" in the standard mode.

The acquisition start trigger of the standard mode is not available in the legacy mode.

For more information about standard mode and legacy mode and how to set them, see Section 9.1 on page 83.

The acquistion start trigger is used to begin frame acquisition. Assuming that the camera is in a "waiting for acquistion start trigger" acquisition status, it will begin a frame acquisition each time it receives an acquistion start trigger signal.

Note that in order for the camera to be in a "waiting for acquistion start trigger" acquisition status:

- The Acquisition Mode parameter must be set correctly.
- A proper Acquisition Start command must be applied to the camera.

For more information about the Acquisition Mode parameter and about Acquisition Start and Acquisition Stop commands, see Section 9.2 on page 85 and Section 9.3 on page 89.

Referring to the use case diagrams that appear in Section 9.8 on page 123 can help you understand the explanations of the acquistion start trigger. Remember, however, that the diagrams apply to the standard mode. Accordingly, the acquisition start trigger shown in the diagrams is not available in legacy mode and the frame start trigger shown is equivalent to the acquisition start trigger in legacy mode.

## 9.6.1 Acquisition Start Trigger Mode (Legacy Mode)

The main parameter associated with the acquisition start trigger is the Trigger Mode parameter. The Trigger Mode parameter for the acquisition start trigger has two available settings: off and on.

### 9.6.1.1 Acquisition Start Trigger Mode = Off

When the Acquisition Start Trigger Mode parameter is set to off, the camera will generate all required acquisition start trigger signals internally, and you do not need to apply acquisition start trigger signals to the camera.

With the trigger mode set to off, the way that the camera will operate the acquisition start trigger depends on the setting of the camera's Acquisition Mode parameter:

- If the Acquisition Mode parameter is set to single frame, the camera will automatically generate a single acquisition start trigger signal whenever it receives an Acquisition Start command.
- If the Acquisition Mode parameter is set to continuous frame, the camera will automatically begin generating acquisition start trigger signals when it receives an Acquisition Start command. The camera will continue to generate acquisition start trigger signals until it receives an Acquisition Stop command.

  The rate at which the acquisition start trigger signals are generated will be determined by the camera's Acquisition Frame Rate Abs parameter:

  - If the parameter is not enabled, the camera will generate acquisition start trigger signals at the maximum rate allowed with the current camera settings.
  - If the parameter is enabled and is set to a value less than the maximum allowed frame rate with the current camera settings, the camera will generate acquisition start trigger signals at the rate specified by the parameter setting.
  - If the parameter is enabled and is set to a value greater than the maximum allowed frame rate with the current camera settings, the camera will generate acquisition start trigger signals at the maximum allowed frame rate.

For information about setting the Acquistion Frame Rate Abs parameter, see Section 9.6.1.3 on page 112.

| | |
|---|---|
| | Keep in mind that the camera will only react to acquisition start triggers when it is in a "waiting for acquisition start trigger" acquisition status. For more information about the acquisition status, see Section 9.2 on page 85 and Section 9.4 on page 91. |

#### Exposure Time Control with the Acquisition Start Trigger Mode Off

When the Trigger Mode parameter for the acquisition start trigger is set to off, the exposure time for each frame acquisition is determined by the camera's exposure time parameters.

For more information about the camera's exposure time parameters, see Section 9.7 on page 121.

### 9.6.1.2 Acquisition Start Trigger Mode = On

When the Trigger Mode parameter for the acquisition start trigger is set to on, you must apply an acquisition start trigger signal to the camera each time you want to begin a frame acquisition. The Trigger Source parameter specifies the source signal that will act as the acquisition start trigger signal. The available selections for the Trigger Source parameter are:

- Software - When the source signal is set to software, you apply an acquisition start trigger signal to the camera by executing a Trigger Software command for the acquisition start trigger on the host PC.
- Line 1 - When the source signal is set to line 1, you apply an acquisition start trigger signal to the camera by injecting an externally generated electrical signal (commonly referred to as a hardware trigger signal) into physical input line 1 on the camera.

If the Trigger Source parameter is set to Line 1, you must also set the Trigger Activation parameter. The available settings for the Trigger Activation parameter are:

- Rising Edge - specifies that a rising edge of the electrical signal will act as the acquisition start trigger.
- Falling Edge - specifies that a falling edge of the electrical signal will act as the acquisition start trigger.

For more information about using a software trigger to control frame acquisition start, see Section 9.4.4 on page 95.

For more information about using a hardware trigger to control frame acquisition start, see Section 9.4.5 on page 96.

By default, input line 1 is selected as the source signal for the acquisition start trigger.

Keep in mind that the camera will only react to acquisition start triggers when it is in a "waiting for acquisition start trigger" acquisition status. For more information about the acquisition status, see Section 9.2 on page 85 and Section 9.4 on page 91.

#### Exposure Time Control with the Acquisition Start Trigger Mode On

When the Trigger Mode parameter for the acquisition start trigger is set to on and the Trigger Source parameter is set to software, the exposure time for each frame acquisition is determined by the camera’s exposure time parameters.

When the Trigger Mode parameter is set to on and the Trigger Source parameter is set to input line 1, the exposure time for each frame acquisition can be controlled with the exposure time parameters or it can be controlled by manipulating the hardware trigger signal.

For more information about controlling exposure time when using a software trigger, see Section 9.4.4 on page 95.

For more information about controlling exposure time when using a hardware trigger, see Section 9.4.5 on page 96.

For more information about exposure time parameters, see Section 9.7 on page 121.

### 9.6.1.3 Setting the Acquisition Start Trigger Mode and Related Parameters

You can set the Trigger Mode and related parameter values for the frame start trigger from within your application software by using the Basler pylon API. If your settings make it necessary, you can also set the Trigger Source parameter.

The following code snippet illustrates using the API to set the Trigger Mode for the acquisition start trigger to on and the Trigger Source to input line 1:

```
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
```

The following code snippet illustrates using the API to set the Acquisition Mode to continuous, the Trigger Mode to off, and the Acquisition Frame Rate to 60:

```
// Set the acquisition mode to continuous frame
Camera.AcquisitionMode.SetValue( AcquisitionMode_Continuous );
// Select the frame start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_Off );
// Set the exposure time
Camera.ExposureTimeAbs.SetValue( 3000 );
// Enable the acquisition frame rate parameter and set the frame rate. (Enabling
// the acquisition frame rate parameter allows the camera to control the frame
// rate internally.)
Camera.AcquisitionFrameRateEnable.SetValue( true );
Camera.AcquisitionFrameRateAbs.SetValue( 60.0 );
// Start frame capture
Camera.AcquisitionStart.Execute( );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

## 9.6.2 Using a Software Acquisition Start Trigger (Legacy Mode)

### 9.6.2.1 Introduction

If the Trigger Mode parameter for the acquisition start trigger is set to on and the Trigger Source parameter is set to software, you must apply a software acquisition start trigger signal to the camera to begin each frame acquisition. Assuming that the camera is in a "waiting for acquisition start trigger" acquisition status, frame exposure will start when the software acquisition start trigger signal is received by the camera. Figure 27 illustrates frame acquisition with a software acquisition start trigger signal.

When the camera receives a software trigger signal and begins exposure, it will exit the "waiting for acquisition start trigger" acquisition status because at that point, it cannot react to a new acquisition start trigger signal. As soon as the camera is capable of reacting to a new acquisition start trigger signal, it will automatically return to the "waiting for acquisition start trigger" acquisition status.

When you are using a software trigger signal to start each frame acquisition, the camera's Exposure Mode parameter must be set to timed. The exposure time for each acquired frame will be determined by the camera's exposure time parameters.

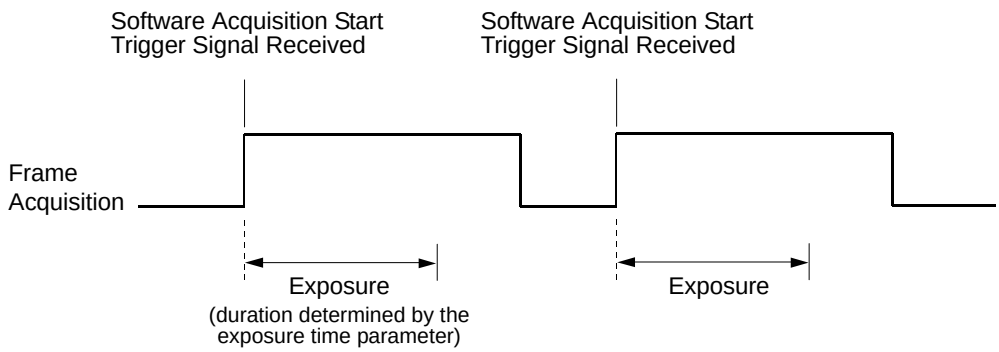



Fig. 31: Frame Acquisition with a Software Acquisition Start Trigger

When you are using a software trigger signal to start each frame acquisition, the frame rate will be determined by how often you apply a software trigger signal to the camera, and you should not attempt to trigger frame acquisition at a rate that exceeds the maximum allowed for the current camera settings. (There is a detailed explanation about the maximum allowed frame rate at the end of this chapter.) Software acquisition start trigger signals that are applied to the camera when it is not ready to receive them will be ignored.

Section 9.5.2.2 on page 103 includes more detailed information about applying a software acquisition start trigger to the camera using Basler pylon.

For more information about determining the maximum allowed frame rate, see Section 9.12 on page 144.

For more information about exposure time parameters, see Section 9.7 on page 121.

### 9.6.2.2 Setting the Parameters Related to Software Acquisition Start Triggering and Applying a Software Trigger Signal

You can set all of the parameters needed to perform software acquisition start triggering from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the parameter values and to execute the commands related to software acquisition start triggering with the camera set for continuous frame acquisition mode:

```
// Set the acquisition mode to continuous frame
Camera.AcquisitionMode.SetValue( AcquisitionMode_Continuous );
// Select the acquisition start trigger
// Disable the acquisition frame rate parameter (this will disable the camera's
// internal frame rate control and allow you to control the frame rate with
// software frame start trigger signals)
Camera.AcquisitionFrameRateEnable.SetValue( false );
// Select the frame start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Software );
// Set for the timed exposure mode
Camera.ExposureMode.SetValue( ExposureMode_Timed );
// Set the exposure time
Camera.ExposureTimeAbs.SetValue( 3000 );
// Execute an acquisition start command to prepare for frame acquisition
     Camera.AcquisitionStart.Execute( );
     while ( ! finished )
     {
         // Execute a Trigger Software command to apply an acquisition start
         // trigger signal to the camera
         Camera.TriggerSoftware.Execute( );
         // Retrieve acquired frame here
     }
     Camera.AcquisitionStop.Execute( );

// Note: as long as the Trigger Selector is set to AcquisitionStart, executing
// a Trigger Software command will apply a software acquisition start trigger
// signal to the camera
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

# 9.6.3 Using a Hardware Acquisition Start Trigger (Legacy Mode)

## 9.6.3.1 Introduction

If the Trigger Mode parameter for the acquisition start trigger is set to on and the Trigger Source parameter is set to input line 1, an externally generated electrical signal applied to input line 1 on the camera will act as the acquisition start trigger signal for the camera. This type of trigger signal is generally referred to as a hardware trigger signal or as an external acquisition start trigger signal (ExASTrig).

A rising edge or a falling edge of the ExASTrig signal can be used to trigger frame acquisition. The Trigger Activation parameter is used to select rising edge or falling edge triggering.

Assuming that the camera is in a "waiting for acquisition start trigger" acquisition status, frame acquisition will start whenever the appropriate edge transition is received by the camera.

When the camera receives a hardware trigger signal and begins exposure, it will exit the "waiting for acquisition start trigger" acquisition status because at that point, it cannot react to a new acquisition start trigger signal. As soon as the camera is capable of reacting to a new acquisition start trigger signal, it will automatically return to the "waiting for acquisition start trigger" acquisition status.

When the camera is operating under control of an ExASTrig signal, the period of the ExASTrig signal will determine the rate at which the camera is acquiring frames:

$$\frac{1}{\text{ExASTrig period in seconds}} = \text{Frame Rate}$$

For example, if you are operating a camera with an ExASTrig signal period of 20 ms (0.020 s):

$$\frac{1}{0.020} = 50 \text{ fps}$$

So in this case, the frame rate is 50 fps.

If you are triggering frame acquisition with an ExASTrig signal and you attempt to acquire frames at too high a rate, some of the acquisition trigger signals that you apply will be received by the camera when it is not in a "waiting for acquisition start trigger" acquisition status. The camera will ignore any acquisition start trigger signals that it receives when it is not "waiting for acquisition start trigger". (This situation is commonly referred to as "over triggering" the camera.

To avoid over triggering, you should not attempt to acquire frames at a rate that exceeds the maximum allowed with the current camera settings.

For more information about setting the camera for hardware acquisition start triggering and selecting the input line to receive the ExASTrig signal, see Section 9.6.3.4 on page 119.

For more information about the electrical requirements for input line 1, see Section 7.7.1 on page 64.

For more information about determining the maximum allowed frame rate, see Section 9.12 on page 144.

### 9.6.3.2 Exposure Modes

If you are triggering the start of frame acquisition with an externally generated acquisition start trigger (ExASTrig) signal, two exposure modes are available: timed and trigger width.

#### Timed Exposure Mode

When timed mode is selected, the exposure time for each frame acquisition is determined by the value of the camera's exposure time parameters. If the camera is set for rising edge triggering, the exposure time starts when the ExASTrig signal rises. If the camera is set for falling edge triggering, the exposure time starts when the ExASTrig signal falls. The following figure illustrates timed exposure with the camera set for rising edge triggering.

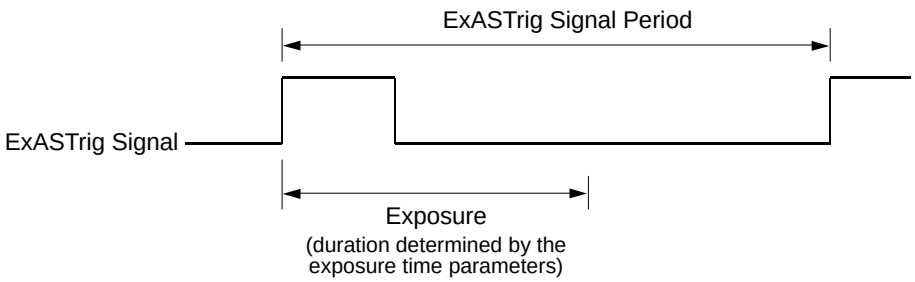



Fig. 32: Timed Exposure with Rising Edge Triggering

Note that if you attempt to trigger a new exposure start while the previous exposure is still in progress, the trigger signal will be ignored. This situation is illustrated below for rising edge triggering.

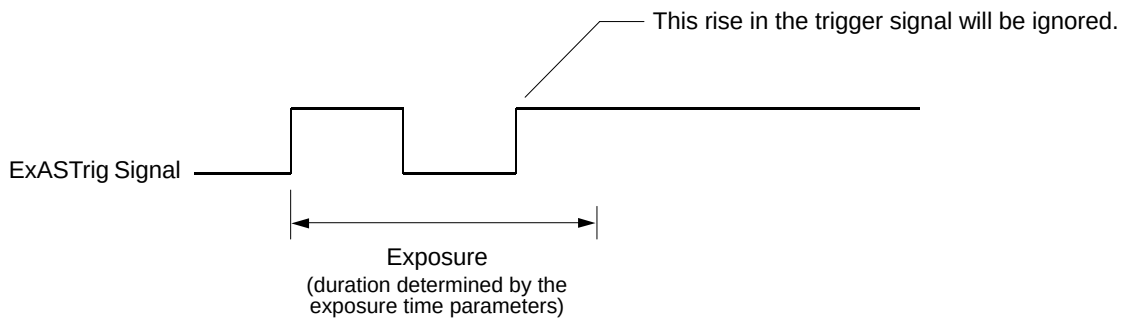

This rise in the trigger signal will be ignored.
ExASTrig Signal
Exposure
(duration determined by the exposure time parameters)

Fig. 33: Overtriggering with Timed Exposure

For more information about the camera's exposure time parameters, see Section 9.7 on page 121.

## Trigger Width Exposure Mode

When trigger width exposure mode is selected, the length of the exposure for each frame acquisition will be directly controlled by the ExASTrig signal. If the camera is set for rising edge triggering, the exposure time begins when the ExASTrig signal rises and continues until the ExASTrig signal falls. If the camera is set for falling edge triggering, the exposure time begins when the ExASTrig signal falls and continues until the ExASTrig signal rises. The following figure illustrates trigger width exposure with the camera set for rising edge triggering.

Trigger width exposure is especially useful if you intend to vary the length of the exposure time for each captured frame.

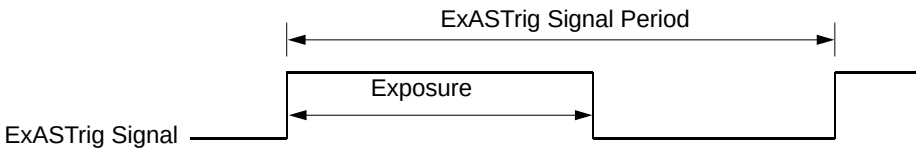



Fig. 34: Trigger Width Exposure with Rising Edge Triggering

When you operate the camera in trigger width exposure mode, you must use the camera's exposure time parameters to set an exposure time. This parameter setting will be used by the camera to operate the Trigger Ready signal.

You should adjust the exposure setting to represent the shortest exposure time you intend to use. For example, assume that you will be using trigger width exposure and that you intend to use the ExASTrig signal to vary the exposure time in a range from 3000 µs to 5500 µs. In this case you would use the exposure setting to set the exposure time to 3000 µs.

If you are using the trigger width exposure mode and the camera is operating with overlapped exposures, there is something you must keep in mind. If the action of the ExASTrig signal would end the current exposure while readout of the previously acquired image is still taking place, the camera will automatically continue the exposure until readout of the previous image is complete. This situation is illustrated in Figure 35 for rising edge operation. On the first cycle of the ExASTrig signal shown in the figure, the signal rises and falls while readout is taking place. Normally you would expect exposure to take place only when the ExASTrig signal is high. But since the signal falls while the previous frame is still reading out, the camera automatically extends exposure until the readout is complete. On the second cycle of the ExASTrig signal shown in the figure, the signal rises during previous frame readout, but falls after the readout is complete. This is a normal situation and exposure would be determined by the high time of the ExASTrig signal as you would expect.

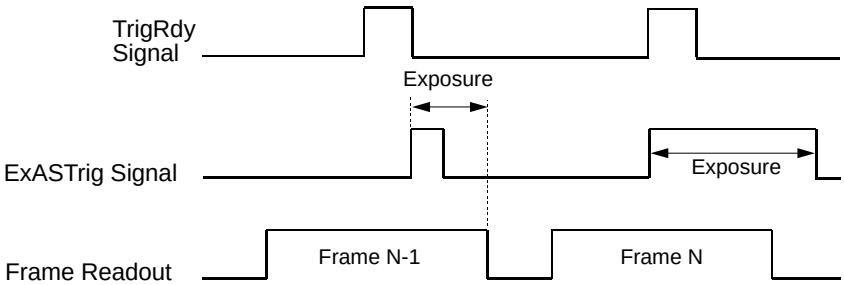



Fig. 35: Trigger Width Exposure Mode with Overlapped Exposure

You can set the exposure time parameter value and select an exposure mode from within your application software by using the pylon API. The following code snippets illustrate using the API to set the exposure time parameter and select the exposure mode:

```
// set for the timed exposure mode, set exposure time to 3000 µs
Camera.ExposureMode.SetValue( ExposureMode_Timed );

Camera.ExposureTimeAbs.SetValue( 3000 );
// set for the width exposure mode, set minimum exposure time to 3000 µs
Camera.ExposureMode.SetValue( ExposureMode_TriggerWidth );
Camera.ExposureTimeAbs.SetValue( 3000 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

### 9.6.3.3 Acquisition Start Trigger Delay

The trigger delay feature lets you specify a delay (in microseconds) that will be applied between the receipt of a hardware acquisition start trigger and when the trigger will become effective.

| | |
|---|---|
| | The trigger delay will not operate if the Trigger Mode parameter for acquisition start is set to off or if you are using a software acquisition start trigger. |

For more information about the trigger delay feature and how to set it, see Section 11.10 on page 193.

### 9.6.3.4 Setting the Parameters Related to Hardware Acquisition Start Triggering and Applying a Hardware Trigger Signal

You can set all of the parameters needed to perform hardware acquisition start triggering from within your application by using the Basler pylon API. The following code snippet illustrates using the API to set the camera for single frame acquisition mode.

We will use the timed exposure mode with input line 1 as the trigger source and with rising edge triggering. In this example, we will use a trigger delay:

```
// Set the acquisition mode to single frame
Camera.AcquisitionMode.SetValue( AcquisitionMode_SingleFrame );
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
// Set the trigger activation mode to rising edge
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
// Set the trigger delay for one millisecond (1000us == 1ms == 0.001s)
double TriggerDelay_us = 1000.0;
Camera.TriggerDelayAbs.SetValue( TriggerDelay_us );
// Set for the timed exposure mode
Camera.ExposureMode.SetValue( ExposureMode_Timed );
// Set the exposure time
Camera.ExposureTimeAbs.SetValue( 3000 );
// Execute an acquisition start command to prepare for frame acquisition
Camera.AcquisitionStart.Execute( );


// Frame acquisition will start when the externally generated
// acquisition start trigger signal (ExASTrig signal)goes high
```

The following code snippet illustrates using the API to set the parameter values and execute the commands related to hardware acquisition start triggering with the camera set for continuous frame acquisition mode.

We will use the trigger width exposure mode with input line 1 as the trigger source and with rising edge triggering:

```
// Set the acquisition mode to continuous frame
Camera.AcquisitionMode.SetValue( AcquisitionMode_Continuous );
// Disable the acquisition frame rate parameter (this will disable the camera’s
// internal frame rate control and allow you to control the frame rate with
// external acquisition start trigger signals)
Camera.AcquisitionFrameRateEnable.SetValue( false );
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Set the mode for the selected trigger
Camera.TriggerMode.SetValue( TriggerMode_On );
```

```
// Set the source for the selected trigger
Camera.TriggerSource.SetValue ( TriggerSource_Line1 );
// Set the trigger activation mode to rising edge
Camera.TriggerActivation.SetValue( TriggerActivation_RisingEdge );
// Set for the trigger width exposure mode
Camera.ExposureMode.SetValue( ExposureMode_TriggerWidth );
// Prepare for frame acquisition here
     Camera.AcquisitionStart.Execute( );
     while ( ! finished )
     {
         // Frame acquisition will start each time the externally generated
         // acquisition start trigger signal (ExASTrig signal)goes high

         // Retrieve the captured frames
     }
     Camera.AcquisitionStop.Execute( );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

# 9.7 Exposure Time Parameters

Many of the camera's image acquisition modes require you to specify an exposure time. There are two ways to set exposure time: by setting "raw" values or by setting an "absolute value". The two methods are described below. You can use whichever method you prefer to set the exposure time.

The exposure time must not be set below a minimum specified value. The minimum exposure time varies by camera model as shown in Table 9.

The maximum exposure time that can be set also varies by camera model as shown in Table 9.

| Camera Model | Minimum Allowed Exposure Time | Maximum Possible Exposure Time |
|---|---|---|
| slA640-74gm/gc | 24 µs | 10000000 µs |
| slA780-54gm/gc | 26 µs | 10000000 µs |
| slA1390-17gm/gc | 34 µs | 10000000 µs |
| slA1400-17gm/gc | 38 µs | 10000000 µs |

Table 9: Minimum Allowed Exposure Time and Maximum Possible Exposure Time

For information about parameter settings for obtaining the maximum possible exposure time, see Section 9.7.1 on page 121.

## 9.7.1 Setting the Exposure Time Using "Raw" Settings

When exposure time is set using "raw" values, the exposure time will be determined by a combination of two elements. The first element is the value of the Exposure Time Raw parameter, and the second element is the Exposure Time Base. The exposure time is determined by the product of these two elements:

Exposure Time = (Exposure Time Raw Parameter Value) x (Exposure Time Base)

By default, the Exposure Time Base is fixed at 20 µs on all camera models.

Typically, the exposure time is adjusted by setting only the Exposure Time Raw parameter. The Exposure Time Raw parameter value can range from 1 to 4095. So if the parameter value was set to 100 on an slA640-74 camera, for example, the exposure time will be 100 x 20 µs or 2000 µs.

### Settings for Obtaining the Maximum Possible Exposure Time

On all camera models, you can obtain the maximum possible exposure time (10000000 µs) by setting the Exposure Time Raw parameter value to 1 and the Exposure Time Base Abs value to 10000000 µs.

### Changing the Exposure Time Base

Normally, the exposure time is adjusted by setting the value of the Exposure Time Raw parameter as explained above. However, if you require an exposure time that is longer than what you can achieve by changing the value of the Exposure Time Raw parameter alone, the Exposure Time Base Abs parameter can be used to change the exposure time base.

The Exposure Time Base Abs parameter value sets the exposure time base in µs and this parameter can be used to change the exposure time base.

On all camera models, the default exposure time base is 20 µs and the time base can be changed in increments of 1 µs.

You can set the Exposure Time Raw and Exposure Time Base Abs parameter values from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter values:

```
Camera.ExposureMode.SetValue( ExposureMode_Timed );
Camera.ExposureTimeRaw.SetValue( 100 );

Camera.ExposureTimeBaseAbs.SetValue( 186 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

## 9.7.2 Setting the Exposure Time Using "Absolute" Settings

You can also set the exposure time by using an "absolute" value. This is accomplished by setting the Exposure Time Abs parameter. The units for setting this parameter are µs and the value can be set in increments of 1 µs.

When you use the Exposure Time Abs parameter to set the exposure time, the camera accomplishes the setting change by automatically changing the Exposure Time Raw parameter to achieve the value specified by your Exposure Time Abs setting. This leads to a limitation that you must keep in mind if you use Exposure Time Abs parameter to set the exposure time. That is, you must set the Exposure Time Abs parameter to a value that is equivalent to a setting you could achieve by using the Exposure Time Raw parameter with the current Exposure Time Base parameter. For example, if the time base was currently set to 62 µs, you could use the Exposure Time Base Abs parameter to set the exposure to 62 µs, 124 µs, 186 µs, etc.

Note that if you set the Exposure Time Abs parameter to a value that you could not achieve by using the Exposure Time Raw and Exposure Time Base parameters, the camera will automatically change the setting for the Exposure Time Abs parameter to the nearest achieveable value.

You should also be aware that if you change the exposure time using the raw settings, the Exposure Time Abs parameter will automatically be updated to reflect the new exposure time.

### Setting the Absolute Exposure Time Parameter

You can set the Exposure Time Abs parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter value:

```
Camera.ExposureTimeAbs.SetValue( 124 );
double resultingExpTime = Camera.ExposureTimeAbs.GetValue( );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

## 9.8 Use Case Diagrams

This section assumes that the standard mode is enabled for image acquisition control.

In principle, this section also applies if the legacy mode is enabled instead. In this case, however, the following differences must be taken into account:

- the acquisition start trigger of the standard mode is not available in the legacy mode.
- the frame start trigger of the standard mode is called "acquisition start trigger" in the legacy mode.

When the camera is started for the first time after delivery from the factory the image acquisition control will not be in standard mode but in legacy mode.

Use the legacy mode only if you want to operate the camera together with previous cameras not featuring the standard mode.

For more information about standard mode and legacy mode and how to set them, see Section 9.1 on page 83.

The following pages contain a series of use case descriptions and diagrams. The descriptions and diagrams are designed to illustrate how acquisition start triggering and frame start triggering work in some common situations and with some common combinations of parameter settings.

These use cases do not represent every possible combination of the parameters associated with acquisition start and frame start triggering. They are simply intended to aid you in developing an initial understanding of how these two triggers interact.

In each use case diagram, the black box in the upper left corner indicates how the parameters are set.

| | |
|---|---|
| | The use case diagrams are representational. They are not drawn to scale and are not designed to accurately describe precise camera timings. |

### Use Case 1 - Acquisition and Frame Start Triggers Both Off (Free Run)

Use case one is illustrated on page 126.

In this use case, the Acquisition Mode parameter is set to continuous. The Trigger Mode parameter for the acquisition start trigger and the Trigger Mode parameter for the frame start trigger are both set to off. The camera will generate all required acquisition start and frame start trigger signals internally. When the camera is set this way, it will constantly acquire images without any need for triggering by the user. This use case is commonly referred to as "free run".

The rate at which the camera will acquire images will be determined by the camera's Acquisition Frame Rate Abs parameter unless the current camera settings result in a lower frame rate. If the Acquisition Frame Rate Abs parameter is disabled, the camera will acquire frames at the maximum allowed frame rate.

Cameras are used in free run for many applications. One example is for aerial photography. A camera set for free run is used to capture a continuous series of images as an aircraft overflies an area. The images can then be used for a variety of purposes including vegetation coverage estimates, archaeological site identification, etc.

For more information about the Acquisition Frame Rate Abs parameter, see Section 9.5.1.1 on page 99 and for information about setting the parameter, see Section 9.5.1.3 on page 101.

**Use Case:** "Free Run" (Acquisition Start Trigger Off and Frame Start Trigger Off)

The acquisition start trigger is off. The camera will generate acquisition start trigger signals internally with no action by the user.

The frame start trigger is off. The camera will generate frame start trigger signals internally with no action by the user.

**Settings:** Acquisition Mode = Continuous
Trigger Mode for the acquisition start trigger = Off
Trigger Mode for the frame start trigger = Off

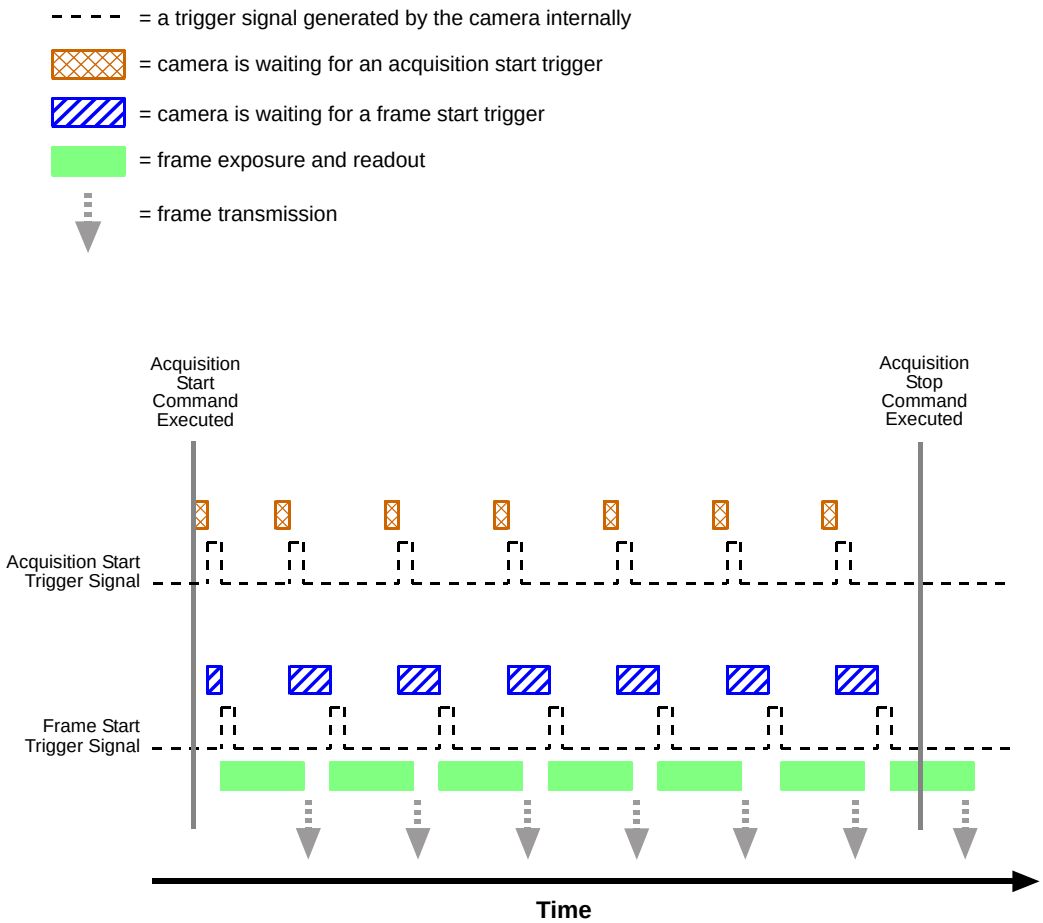

= a trigger signal generated by the camera internally
= camera is waiting for an acquisition start trigger
= camera is waiting for a frame start trigger
= frame exposure and readout
= frame transmission
Acquisition Start Command Executed
Acquisition Stop Command Executed
Acquisition Start Trigger Signal
Frame Start Trigger Signal
Time

Fig. 36: Use Case 1 - Acquisition Start Trigger Off and Frame Start Trigger Off

## Use Case 2 - Acquisition Start Trigger Off - Frame Start Trigger On

Use case two is illustrated on page 128.

In this use case, the Acquisition Mode parameter is set to continuous. The Trigger Mode parameter for the acquisition start trigger is set to off and the Trigger Mode parameter for the frame start trigger is set to on.

Because the acquisition start trigger is set to off, the user does not need to apply acquisition start trigger signals to the camera. The camera will generate all required acquisition start trigger signals internally.

Because the frame start trigger is set to on, the user must apply a frame start trigger signal to the camera in order to begin each frame exposure. In this case, we have set the frame start trigger signal source to input line 1 and the activation to rising edge, so the rising edge of an externally generated electrical signal applied to line 1 will serve as the frame start trigger signal.

This type of camera setup is used frequently in industrial applications. One example might be a wood products inspection system used to inspect the surface of pieces of plywood on a conveyor belt as they pass by a camera. In this situation, a sensing device is usually used to determine when a piece of plywood on the conveyor is properly positioned in front of the camera. When the plywood is in the correct position, the sensing device transmits an electrical signal to input line 1 on the camera. When the electrical signal is received on line 1, it serves as a frame start trigger signal and initiates a frame acquisition. The frame acquired by the camera is forwarded to an image processing system, which will inspect the image and determine if there are any defects in the plywood's surface.

**Use Case:** Acquisition Start Trigger Off and Frame Start Trigger On

The acquisition start trigger is off. The camera will generate acquisition start trigger signals internally with no action by the user.

The frame start trigger is on, and the frame start trigger source is set to input line 1. The user must apply a frame start trigger signal to input line 1 to start each frame exposure.

**Settings:**
Acquisition Mode = Continuous
Trigger Mode for the acquisition start trigger = Off
Trigger Mode for the frame start trigger = On
Trigger Source for the frame start trigger = Line 1
Trigger Activation for the frame start trigger = Rising Edge

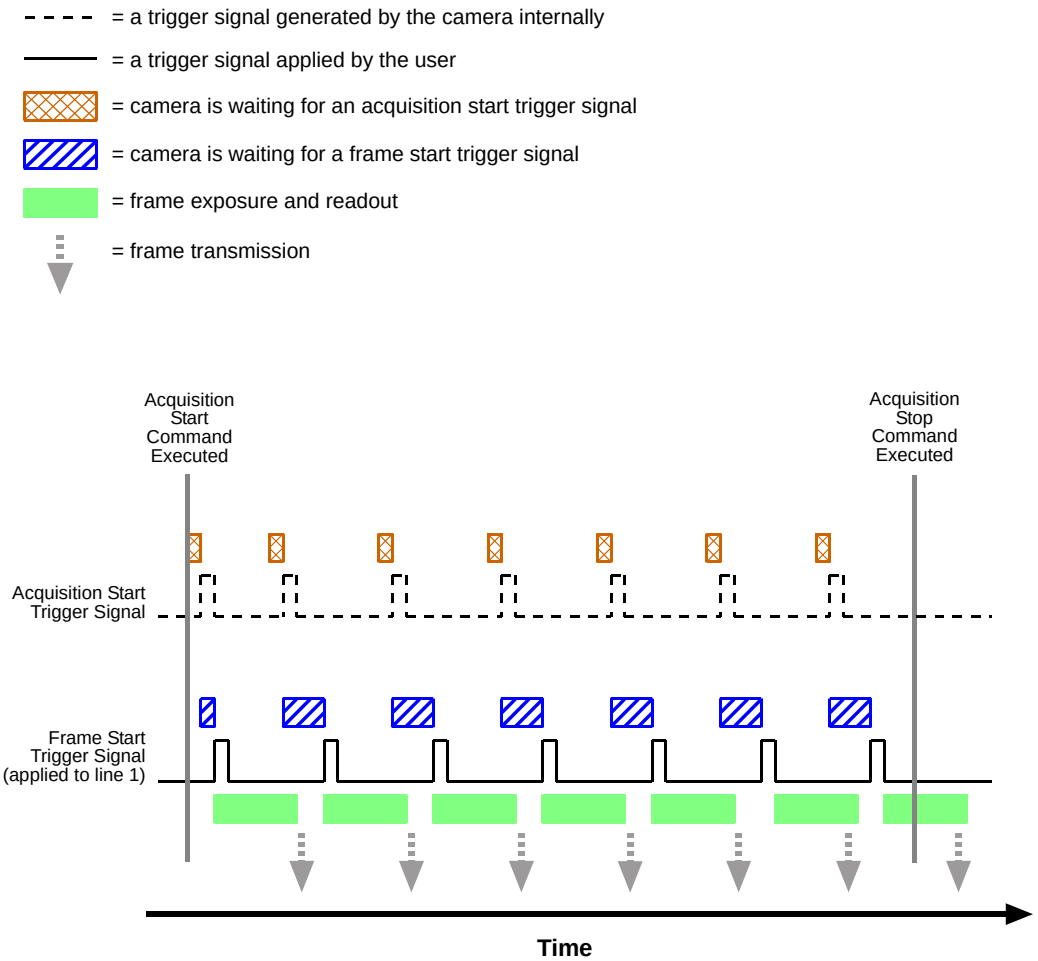

= a trigger signal generated by the camera internally
= a trigger signal applied by the user
= camera is waiting for an acquisition start trigger signal
= camera is waiting for a frame start trigger signal
= frame exposure and readout
= frame transmission
Acquisition Start Command Executed
Acquisition Stop Command Executed
Acquisition Start Trigger Signal
Frame Start Trigger Signal (applied to line 1)
Time

Fig. 37: Use Case 2 - Acquisition Start Trigger Off and Frame Start Trigger On

### Use Case 3 - Acquisition Start Trigger On - Frame Start Trigger Off

Use case three is illustrated on page 130.

In this use case, the Acquisition Mode parameter is set to continuous. The Trigger Mode parameter for the acquisition start trigger is set to on and the Trigger Mode parameter for the frame start trigger is set to off.

Because the acquisition start trigger mode is set to on, the user must apply an acquisition start trigger signal to the camera. In this case, we have set the acquisition start trigger signal source to input line 1 and the activation to rising edge, so an externally generated electrical signal applied to input line 1 will serve as the acquisition start trigger signal. The Acquisition Frame Count parameter has been set to 3.

When a rising edge of the electrical signal is applied to input line 1, the camera will exit the "waiting for acquisition start trigger" acquisition status and enter a "waiting for frame start trigger" acquisition status. Once the camera has acquired 3 frames, it will re-enter the "waiting for acquisition start trigger" acquisition status. Before any more frames can be acquired, a new rising edge must be applied to input line 1 to make the camera exit the "waiting for acquisition start trigger" acquisition status.

Because the frame start trigger is set to off, the user does not need to apply frame start trigger signals to the camera. The camera will generate all required frame start trigger signals internally. The rate at which the frame start trigger signals will be generated is normally determined by the camera’s Acquisition Frame Rate Abs parameter. If the Acquisition Frame Rate Abs parameter is disabled, the camera will acquire frames at the maximum allowed frame rate.

This type of camera setup is used frequently in intelligent traffic systems. With these systems, a typical goal is to acquire several images of a car as it passes through a toll booth. A sensing device is usually placed at the start of the toll booth area. When a car enters the area, the sensing device applies an electrical signal to input line 1 on the camera. When the electrical signal is received on input line 1, it serves as an acquisition start trigger signal and the camera exits from the "waiting for acquisition start trigger" acquisition status and enters a "waiting for frame trigger" acquisition status. In our example, the next 3 frame start trigger signals internally generated by the camera would result in frame acquisitions. At that point, the number of frames acquired would be equal to the setting for the Acquisition Frame Count parameter. The camera would return to the "waiting for acquisition start trigger" acquisition status and would no longer react to frame start trigger signals. It would remain in this condition until the next car enters the booth area and activates the sensing device.

This sort of setup is very useful for traffic system applications because multiple frames can be acquired with only a single acquisition start trigger signal pulse and because frames will not be acquired when there are no cars passing through the booth (this avoids the need to store images of an empty toll booth area.)

For more information about the Acquisition Frame Rate Abs parameter, see Section 9.5.1.1 on page 99 and for information about setting the parameter, see Section 9.5.1.3 on page 101.

**Use Case:** Acquisition Start Trigger On and Frame Start Trigger Off

The acquisition start trigger is on, and the acquisition start trigger source is set to input line 1. The user must apply an acquisition start trigger signal to input line 1 to make the camera exit the "waiting for acquisition start trigger" acquisition status. Because the acquisition frame count is set to 3, the camera will re-enter the "waiting for acquisition start trigger" acquisition status after 3 frames have been acquired.

The frame start trigger is off. The camera will generate frame start trigger signals internally with no action by the user.

**Settings:**
Acquisition Mode = Continuous
Trigger Mode for the acquisition start trigger = On
Trigger Source for the acquisition start trigger = Line 1
Trigger Activation for the acquisition start trigger = Rising Edge
Acquisition Frame Count = 3
Trigger Mode for the frame start trigger = Off

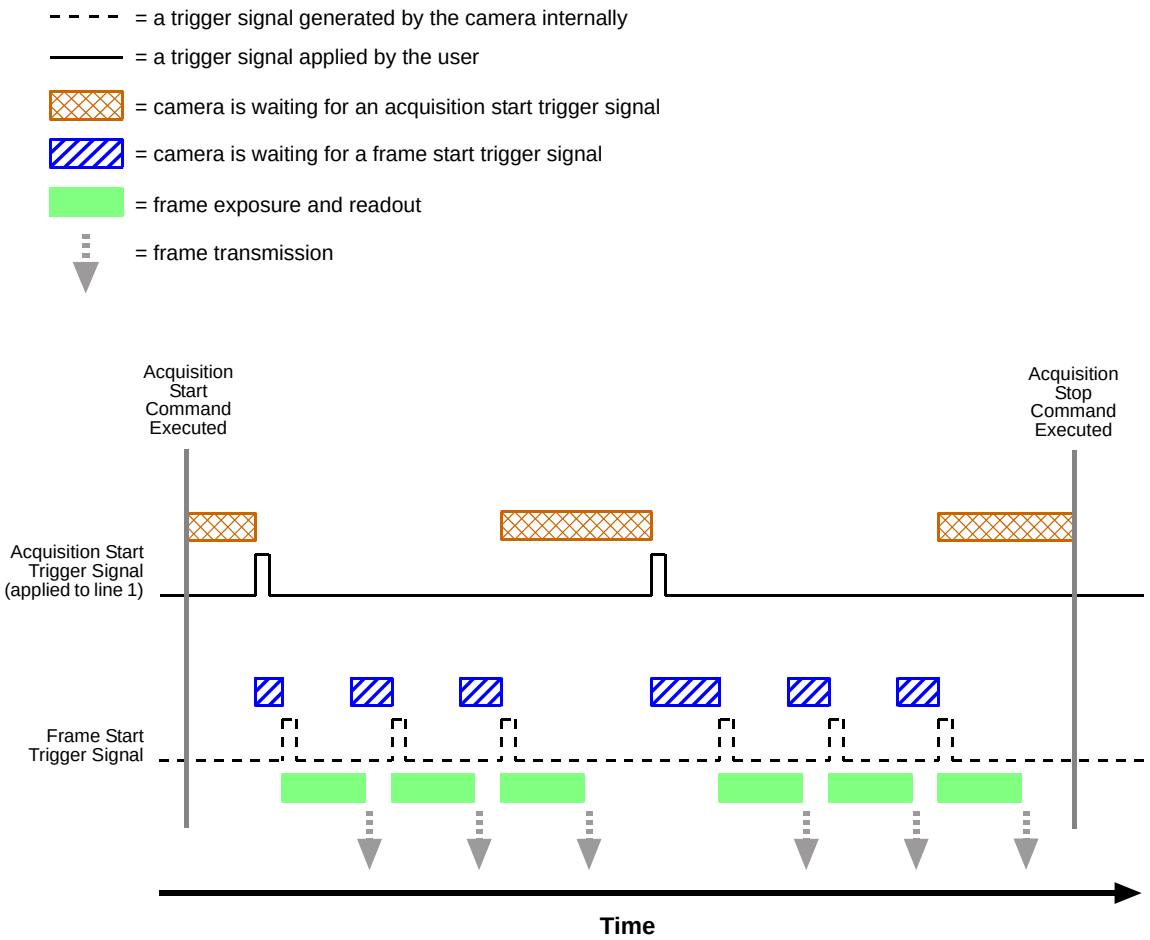

= a trigger signal generated by the camera internally
= a trigger signal applied by the user
= camera is waiting for an acquisition start trigger signal
= camera is waiting for a frame start trigger signal
= frame exposure and readout
= frame transmission
Acquisition Start Command Executed
Acquisition Stop Command Executed
Acquisition Start Trigger Signal (applied to line 1)
Frame Start Trigger Signal
Time

Fig. 38: Use Case 3 - Acquisition Start Trigger On and Frame Start Trigger Off

## Use Case 4 - Acquisition Start and Frame Start Triggers Both On

Use case four is illustrated on page 132.

In this use case, the Acquisition Mode parameter is set to continuous. The Trigger Mode parameter for the acquisition start trigger is set to on and the Trigger Mode parameter for the frame start trigger is set to on.

Because the acquisition start trigger mode is set to on, the user must apply an acquisition start trigger signal to the camera. In this case, we have set the acquisition start trigger signal source to software, so the execution of an acquisition trigger software command will serve as the acquisition start trigger signal. The Acquisition Frame Count parameter is set to 3.

When an acquisition trigger software command is executed, the camera will exit the "waiting for acquisition start trigger" acquisition status and enter a "waiting for frame start trigger" acquisition status. Once the camera has acquired 3 frames, it will re-enter the "waiting for acquisition start trigger" acquisition status. Before any more frames can be acquired, a new acquisition trigger software command must be executed to make the camera exit the "waiting for acquisition start trigger" acquisition status.

Because the frame start trigger is set to on, the user must apply a frame start trigger signal to the camera in order to begin each frame acquisition. In this case, we have set the frame start trigger signal source to input line 1 and the activation to rising edge, so the rising edge of an externally generated electrical signal applied to input line 1 will serve as the frame start trigger signal. Keep in mind that the camera will only react to a frame start trigger signal when it is in a "waiting for frame start trigger" acquisition status.

A possible use for this type of setup is a conveyor system that moves objects past an inspection camera. Assume that the system operators want to acquire images of 3 specific areas on each object, that the conveyor speed varies, and that they do not want to acquire images when there is no object in front of the camera. A sensing device on the conveyor could be used in conjunction with a PC to determine when an object is starting to pass the camera. When an object is starting to pass, the PC will execute an acquisition start trigger software command, causing the camera to exit the "waiting for acquisition start trigger" acquisition status and enter a "waiting for frame start trigger" acquisition status.

An electrical device attached to the conveyor could be used to generate frame start trigger signals and to apply them to input line 1 on the camera. Assuming that this electrical device was based on a position encoder, it could account for the speed changes in the conveyor and ensure that frame trigger signals are generated and applied when specific areas of the object are in front of the camera. Once 3 frame start trigger signals have been received by the camera, the number of frames acquired would be equal to the setting for the Acquisition Frame Count parameter, and the camera would return to the "waiting for acquisition start trigger" acquisition status. Any frame start trigger signals generated at that point would be ignored.

This sort of setup is useful because it will only acquire frames when there is an object in front of the camera and it will ensure that the desired areas on the object are imaged. (Transmitting images of the "space" between the objects would be a waste of bandwidth and processing them would be a waste of processor resources.)

**Use Case:** Acquisition Start Trigger On and Frame Start Trigger On

The acquisition start trigger is on, and the acquisition start trigger source is set to software. The user must execute an acquisition start trigger software command to make the camera exit the "waiting for acquisition start trigger" acquisition status. Because the acquisition frame count is set to 3, the camera will re-enter the "waiting for acquisition start trigger" acquisition status after 3 frame trigger signals have been applied.

The frame start trigger is on, and the frame start trigger source is set to input line 1. The user must apply a frame start trigger signal to input line 1 to start each frame exposure.

**Settings:**
Acquisition Mode = Continuous
Trigger Mode for the acquisition start trigger = On
Trigger Source for the acquisition start trigger = Software
Acquisition Frame Count = 3
Trigger Mode for the frame start trigger = On
Trigger Source for the frame start trigger = Line 1
Trigger Activation for the frame start trigger = Rising Edge

= a trigger signal applied by the user

= camera is waiting for an acquisition start trigger signal

= camera is waiting for a frame start trigger signal

= frame exposure and readout

= frame transmission

= a frame start trigger signal that will be ignored because the camera is not in a "waiting for frame start trigger" status

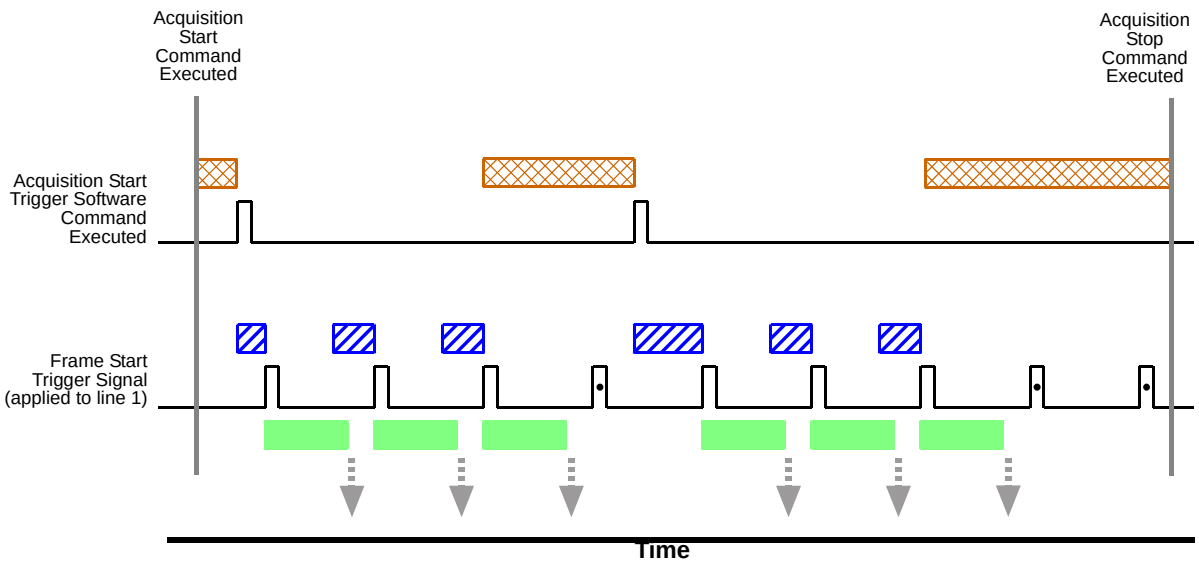

Acquisition Start Command Executed
Acquisition Stop Command Executed
Acquisition Start Trigger Software Command Executed
Frame Start Trigger Signal (applied to line 1)
Time

Fig. 39: Use Case 4 - Acquisition Start Trigger On and Frame Start Trigger On

# 9.9 Overlapping Exposure and Sensor Readout

The image acquisition process on the camera includes two distinct parts. The first part is the exposure of the pixels in the imaging sensor. Once exposure is complete, the second part of the process – readout of the pixel values from the sensor – takes place.

In regard to this image acquisition process, there are two common ways for the camera to operate: with “non-overlapped” exposure and with “overlapped” exposure. In the non-overlapped mode of operation, each time an image is acquired, the camera completes the entire exposure/readout process before acquisition of the next image is started. This situation is illustrated in Figure 40.

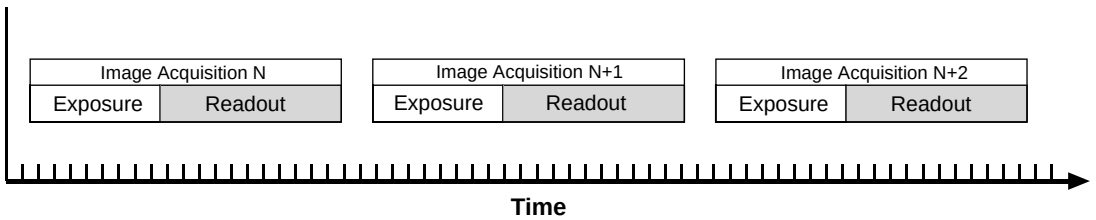



Fig. 40: Non-overlapped Exposure

While operating in a non-overlapped fashion is perfectly normal and is appropriate for many situations, it is not the most efficient way to operate the camera in terms of acquisition frame rate. On this camera, however, it is allowable to begin exposing a new image while a previously acquired image is being read out. This situation is illustrated in Figure 41 and is known as operating the camera with “overlapped” exposure.

As you can see, running the camera with readout and exposure overlapped can allow higher acquisition frame rates because the camera is performing two processes at once.

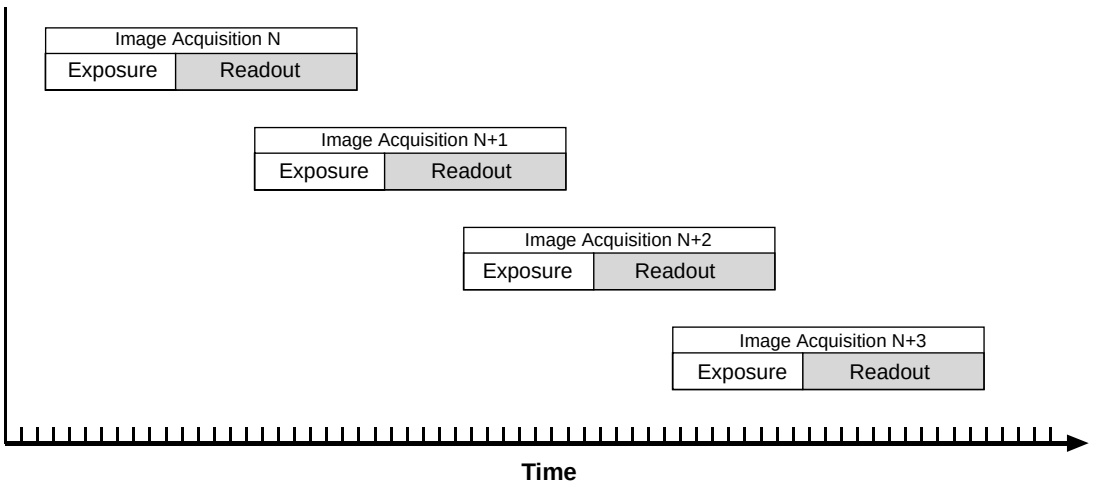



Fig. 41: Overlapped Exposure

Determining whether your camera is operating with overlapped or non-overlapped exposures is not a matter of issuing a command or switching a setting on or off. Rather the way that you operate the camera will determine whether the exposures are overlapped or not overlapped. If we define the “frame period” as the time from the start of exposure for one image acquisition to the start of exposure for the next image acquisition, then:

- Exposure will overlap when: Frame Period ≤ Exposure Time + Readout Time
- Exposure will not overlap when: Frame Period > Exposure Time + Readout Time

You can calculate the readout time for a captured image by using the formula on page 142.

## 9.9.1 Guidelines for Overlapped Operation

If you will be operating the camera with overlapped exposure, there are two important guidelines to keep in mind:

- You must not begin the exposure time for a new image acquisition while the exposure time of the previous acquisition is in progress.
- You must not end the exposure time of the current image acquisition until readout of the previously acquired image is complete.

The camera will ignore any trigger signals that violate these guidelines.

When you are operating a camera with overlapped exposure and using a hardware trigger signal to trigger image acquisition, you could use the camera’s exposure time parameter settings and timing formulas to calculate when it is safe to begin each new acquisition. However, there is a much more convenient way to know when it safe to begin each acquisition. The camera supplies a “trigger ready” signal that is specifically designed to let you trigger overlapped exposure safely and efficiently.

For more information about using the Trigger Ready signal, see Section 9.10.3 on page 136.

For more detailed guidelines about using an external trigger signal with the trigger width exposure mode and overlapped exposure, refer to the application notes called "Using a Specific External Trigger Signal with Overlapped Exposure" (AW000565xx000). The application notes are available in the downloads section of the Basler website: www.baslerweb.com.

# 9.10 Acquisition Monitoring Tools

## 9.10.1 Exposure Active Signal

The camera's "exposure active" (ExpAc) signal goes high when the exposure time for each image acquisition begins and goes low when the exposure time ends as shown in Figure 42. This signal can be used as a flash trigger and is also useful when you are operating a system where either the camera or the object being imaged is movable. For example, assume that the camera is mounted on an arm mechanism and that the mechanism can move the camera to view different portions of a product assembly. Typically, you do not want the camera to move during exposure. In this case, you can monitor the ExpAc signal to know when exposure is taking place and thus know when to avoid moving the camera.

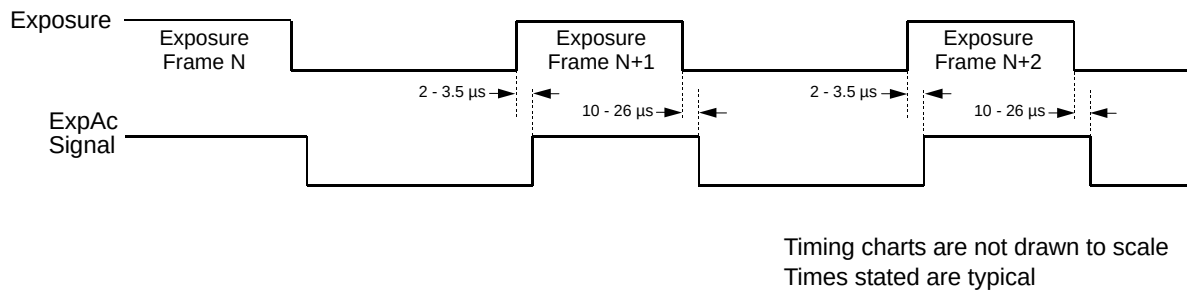



Fig. 42: Exposure Active Signal

| | |
|---|---|
| | When you use the exposure active signal, be aware that there is a delay in the rise and the fall of the signal in relation to the start and the end of exposure. See Figure 42 for details. |

By default, the ExpAc signal is assigned to physical output line 1 on the camera.

### Selecting the Exposure Active Signal as the Source Signal for the Output Line

The exposure active output signal can be selected to act as the source signal for output line 1. Selecting a source signal for the output line is a two step process:

- Use the Line Selector to select output line 1.
- Set the value of the Line Source Parameter to the exposure active output signal.

You can set the Line Selector and the Line Source parameter value from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.LineSelector.SetValue( LineSelector_Out1 );
Camera.LineSource.SetValue( LineSource_ExposureActive );
```

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about changing the assignment of camera output signals to the physical output line, see Section 8.2.1 on page 73.

For more information about the electrical characteristics of the camera's output line, see Section 7.7.2 on page 67.

## 9.10.2 Acquisition Status Indicator

When controlling image acquisition with a software trigger you can use the acquisition status feature to determine when the camera is rady to be triggered for an image acquisition.

For more information about the acquisition status feature, see Section 11.11 on page 195.

## 9.10.3 Trigger Ready Signal

As described in the previous section, the cameras can operate in an "overlapped" acquisition fashion. When the camera is operated in this manner, it is especially important that:

- the exposure time of a new image acquisition not start until exposure of the previously acquired image is complete, and
- the exposure time of a new image acquisition not end until readout of the previously acquired image is complete.

The camera supplies a "Trigger Ready" (TrigRdy) output signal you can use to ensure that these conditions are met when you are using a hardware trigger signal to trigger image acquisition. The trigger ready signal relates to different trigger signals, depending on the image acquisition control mode:

- In standard mode, the trigger ready signal relates to the frame start trigger signal
- In legacy mode, the trigger ready signal relates to the acquisition start trigger signal.

When you are acquiring images, the camera automatically calculates the earliest moment that it is safe to trigger each new acquisition. The trigger ready signal will go high when it is safe to trigger an acquisition, will go low when the acquisition has started, and will go high again when it is safe to trigger the next acquisition (see Figure 43). The camera calculates the rise of the trigger ready signal based on the current exposure time parameter setting, the current size of the area of interest, and the time it will take to readout the captured pixel values from the sensor.

The trigger ready signal is especially useful if you want to run the camera at the maximum acquisition frame capture rate for the current conditions. If you monitor the trigger ready signal and you trigger acquisition of each new image immediately after the signal goes high, you will be sure that the camera is operating at the maximum acquisition frame rate for the current conditions.

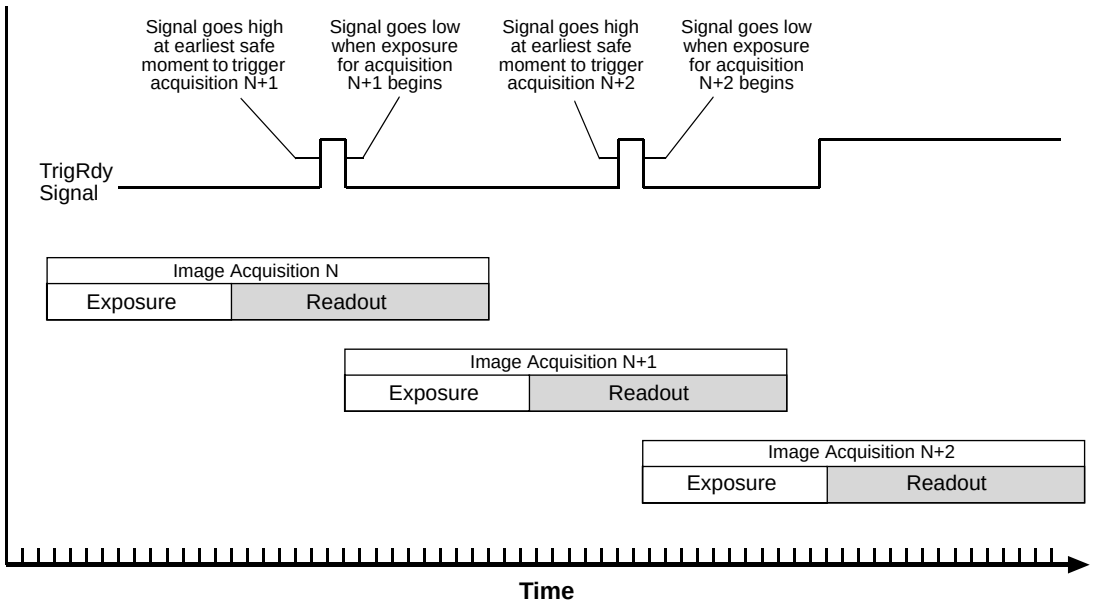



Fig. 43: Trigger Ready Signal

You should be aware that if the Acquisition Frame Rate Abs parameter is enabled, the operation of the trigger ready signal will be influenced by the value of the parameter:

- If the value of the parameter is greater than zero but less than the maximum allowed, the trigger ready will go high at the rate specified by the parameter value. For example, if the parameter is set to 10, the trigger ready signal will go high 10 times per second.
- If the value of the parameter is greater than the maximum allowed acquisition frame rate with the current camera settings, the trigger ready signal will work as described above and will go high at a point that represents the maximum acquisition frame rate allowed.

| | |
|---|---|
| | If you attempt to start an image acquisition when the trigger ready signal is low, the camera will simply ignore the attempt.<br>The trigger ready signal will only be available when hardware triggering is enabled. |

The trigger ready signal can be assigned to physical output line 1 on the camera.

## Selecting the Trigger Ready Signal as the Source Signal for the Output Line

The trigger ready signal can be selected to act as the source signal for output line 1. Selecting a source signal for the output line is a two step process:

- Use the Line Selector to select output line 1.
- Set the value of the Line Source Parameter to the trigger ready output signal.

You can set the Line Selector and the Line Source parameter value from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.LineSelector.SetValue( LineSelector_Out1 );
Camera.LineSource.SetValue( LineSource_TriggerReady );
```

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about changing the assignment of camera output signals to the physical output line, see Section 8.2.1 on page 73.

For more information about the electrical characteristics of the camera's output line, see Section 7.7.2 on page 67.

For more information about the standard and legacy image acquisition control modes, see Section 9.1 on page 83.

## 9.10.4 Acquisition Trigger Wait Signal (Standard Mode Only)

The acquisition trigger wait signal is only available when the image acquisition control is set to standard mode.

For more information about image acquisition control and setting the mode, see Section 9.1 on page 83.

As you are acquiring frames, the camera automatically monitors the acquisition start trigger status and supplies a signal that indicates the current status. The Acquisition Trigger Wait signal will go high whenever the camera enters a "waiting for acquisition start trigger" status. The signal will go low when an external acquisition start trigger (ExASTrig) signal is applied to the camera and the camera exits the "waiting for acquisition start trigger status". The signal will go high again when the camera again enters a "waiting for acquisition trigger" status and it is safe to apply the next acquisition start trigger signal.

If you base your use of the ExASTrig signal on the state of the acquisition trigger wait signal, you can avoid "acquisition start overtriggering", i.e., applying an acquisition start trigger signal to the camera when it is not in a "waiting for acquisition start trigger" acquisition status. If you do apply an acquisition start trigger signal to the camera when it is not ready to receive the signal, it will be ignored.

Figure 44 illustrates the Acquisition Trigger Wait signal with the Acquisition Frame Count parameter set to 3 and with exposure and readout overlapped. The figure assumes that the trigger mode for the frame start trigger is set to off, so the camera is internally generating frame start trigger signals.

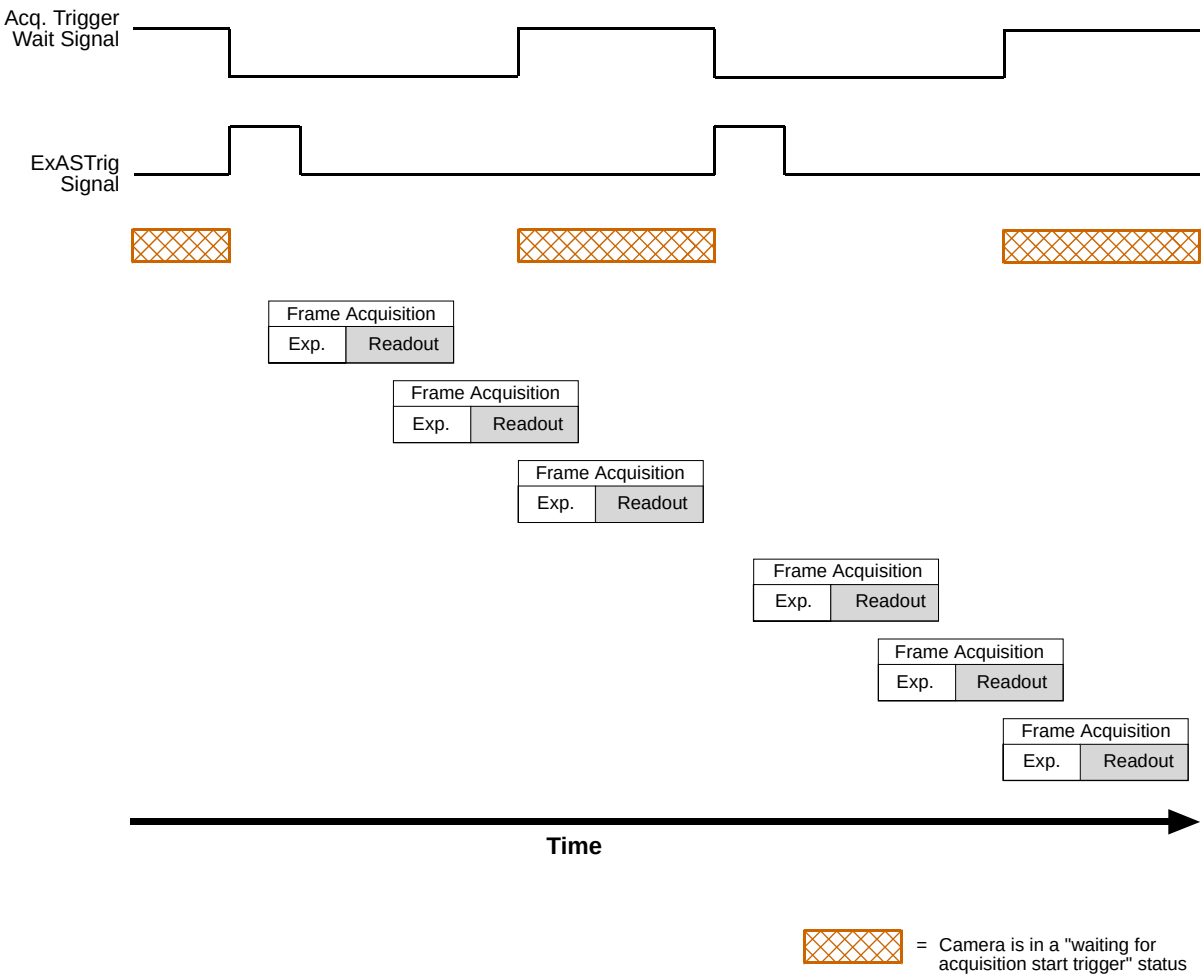



Fig. 44: Acquisition Trigger Wait Signal

| | |
|---|---|
| | The acquisition trigger wait signal will only be available when hardware acquisition start triggering is enabled. |

## Selecting the Acquisition Trigger Wait Signal as the Source Signal for the Output Line

The acquisition trigger wait signal can be selected to act as the source signal for camera output line 1. Selecting a source signal for the output line is a two step process:

- Use the Line Selector to select output line 1.
- Set the value of the Line Source Parameter to the acquisition trigger wait signal.

You can set the Line Selector and the Line Source parameter value from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.LineSelector.SetValue( LineSelector_Out1 );
Camera.LineSource.SetValue( LineSource_AcquisitionTriggerWait );
```

You can also use the Basler pylon Viewer application to easily set the parameters.

# 9.11 Acquisition Timing Chart

Figure 45 shows a timing chart for image acquisition and transmission. The chart assumes that exposure is triggered by an ExTrig signal with rising edge activation and that the camera is set for the timed exposure mode.

The ExTrig signal will be an externally triggered frame start trigger signal when using image acquisition control in standard mode. The ExTrig signal will be an externally triggered acquisition start trigger signal when using image acquisition control in legacy mode.

As Figure 45 shows, there is a slight delay between the rise of the ExTrig signal and the start of exposure. After the exposure time for an image acquisition is complete, the camera begins reading out the acquired image data from the CCD sensor into a buffer in the camera. When the camera has determined that a sufficient amount of image data has accumulated in the buffer, it will begin transmitting the data from the camera to the host PC.

This buffering technique avoids the need to exactly synchronize the clock used for sensor readout with the data transmission over your Ethernet network. The camera will begin transmitting data when it has determined that it can safely do so without over-running or under-running the buffer. This buffering technique is also an important element in achieving the highest possible frame rate with the best image quality.

The **exposure start delay** is the amount of time between the point where the trigger signal transitions and the point where exposure actually begins.

The **frame readout time** is the amount of time it takes to read out the data for an acquired image from the CCD sensor into the image buffer.

The **frame transmission time** is the amount of time it takes to transmit the acquired image from the buffer in the camera to the host PC via the network.

The **transmission start delay** is the amount of time between the point where the camera begins reading out the acquired image data from the sensor to the point where it begins transmitting the data for the acquired image from the buffer to the host PC.

The exposure start delay varies from camera model to camera model. The table below shows the exposure start delay for each camera model:

| Camera Model | Exposure Start Delay | Camera Model | Exposure Start Delay |
|---|---|---|---|
| slA640-74gm/gc | 30.05 µs | slA1390-17gm/gc | 65.31 µs |
| slA780-54gm/gc | 35.94 µs | slA1400-17gm/gc | 63.17 µs |

Table 10: Exposure Start Delays

Note that, if the debouncer feature is used, the debouncer setting for the input line must be added to the exposure start delays shown in Table 10 to determine the total start delay. For example, assume that you are using an slA640-74 camera and that you have set the cameras for hardware triggering. Also assume that you have selected input line 1 to accept the hardware trigger signal and that you have set the Line Debouncer Time Abs parameter for input line 1 to 5 µs.

In this case:

Total Start Delay = Start Delay from Table 10 + Debouncer Setting

Total Start Delay = 30.05 µs+ 5 µs

Total Start Delay = 35.05 µs

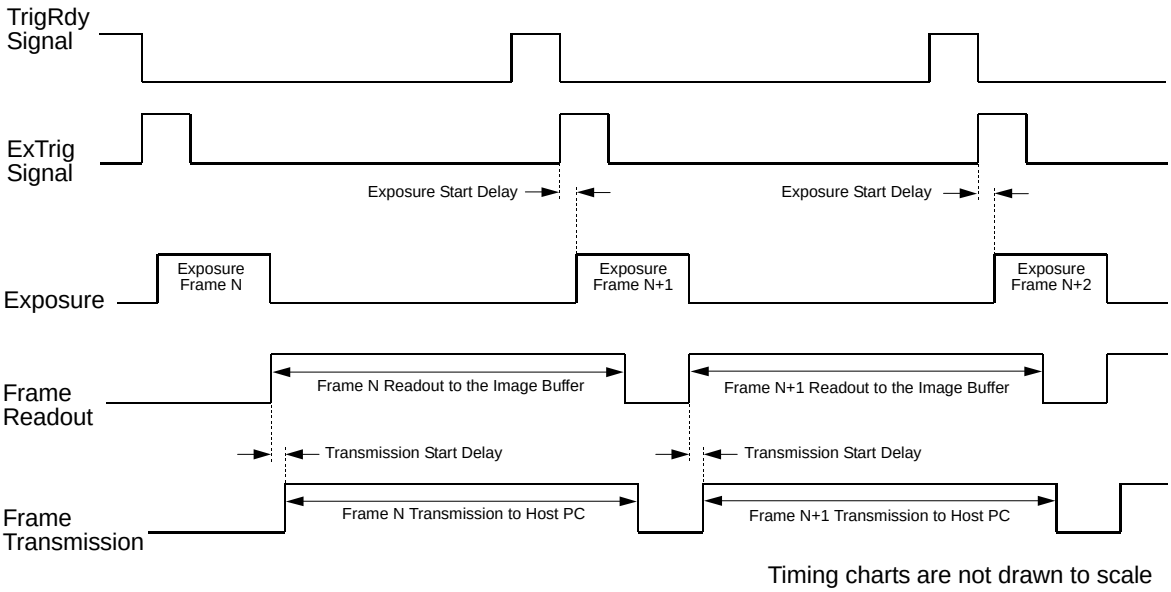



Fig. 45: Exposure Start Controlled with an ExTrig Signal

You can calculate the frame readout time by using this formula:

Frame Readout Time = ( (AOI Height + 1) x $C_1$ ) + $C_2$

Where the values for the constants $C_1$ and $C_2$ are from the table in Section 9.12 on page 144 for all camera models.

For more information about the AOI height, see Section 11.6 on page 185.

You can calculate an approximate frame transmission time by using this formula:

$$\sim \text{Frame Transmission Time} = \frac{\text{Payload Size Parameter Value}}{\text{Device Current Throughput Parameter Value}}$$

Note that this is an approximate frame transmission time. Due to the nature of the Ethernet network, the transmission time could vary. Also note that the frame transmission cannot be less than the frame readout time. So if the frame transmission time formula returns a value that is less than the readout time, the approximate frame transmission time will be equal to the readout time.

Due to the nature of the Ethernet network, the transmission start delay can vary from frame to frame. The transmission start delay, however, is of very low significance when compared to the transmission time.

For more information about the Payload Size and Device Current Throughput parameters, see Section 5.1 on page 39.

# 9.12 Maximum Allowed Acquisition Frame Rate

In general, the maximum allowed acquisition frame rate can be limited by three factors:

- The amount of time it takes to read an acquired frame out of the imaging sensor and into the camera's frame buffer. This time varies depending on the height of the frame. Frames with a smaller height take less time to read out of the sensor. The frame height is determined by the camera's AOI Height settings.
- The exposure time for acquired frames. If you use very long exposure times, you can acquire fewer frames per second.
- The amount of time that it takes to transmit an acquired frame from the camera to your host PC. The amount of time needed to transmit a frame depends on the bandwidth assigned to the camera.

When the camera's acquisition mode is set to single frame, the maximum possible acquisition frame rate for a given AOI cannot be achieved. To achieve the maximum possible acquisition frame rate, set the camera for the continuous acquisition mode.

To determine the maximum allowed acquisition frame rate with your current camera settings, you can read the value of the camera's Resulting Frame Rate parameter. This parameter indicates the camera's current maximum allowed frame rate taking the AOI, exposure time, and bandwidth settings into account.

For more information about the acquisition mode, see Section 9.2 on page 85 and Section 9.3 on page 89.

For more information about AOI Height settings, see Section 11.6 on page 185.

For more information about the Resulting Frame Rate parameter, see Section 5.1 on page 39.

### Increasing the Maximum Allowed Frame Rate

You may find that you would like to acquire frames at a rate higher than the maximum allowed with the camera's current settings. In this case, you must first use the three formulas described below to determine which factor is restricting the maximum frame rate the most. Next, you must try to make that factor less restrictive:

- You will often find that the sensor readout time is most restrictive factor. Decreasing the AOI height for the acquired frames will decrease the sensor readout time and will make this factor less restrictive.
- If you are using normal exposure times and you are using the camera at it's maximum resolution, your exposure time will not normally be the most restrictive factor on the frame rate. However, if you are using long exposure times or small areas of interest, it is quite possible to

find that your exposure time is the most restrictive factor on the frame rate. In this case, you should lower your exposure time. (You may need to compensate for a lower exposure time by using a brighter light source or increasing the opening of your lens aperture.)

- The frame transmission time will not normally be a restricting factor. But if you are using multiple cameras and you have set a small packet size or a large inter-packet delay, you may find that the transmission time is restricting the maximum allowed rate. In this case, you could increase the packet size or decrease the inter-packet delay. If you are using several cameras connected to the host PC via a network switch, you could also use a multiport network adapter in the PC instead of a switch. This would allow you to increase the Ethernet bandwidth assigned to the camera and thus decrease the transmission time.

For more information about AOI settings, see Section 11.6 on page 185.

For more information on the settings that determine the bandwidth assigned to the camera, see Section 5.2 on page 46.

**Formula 1:**

Calculates the maximum frame rate based on the sensor readout time:

$$\text{Max. Frames/s} = \frac{1}{[(\text{AOI Height} + 1) \times C_1] + C_2}$$

Where:

AOI Height = the height of the acquired frames as determined by the AOI Height settings.

The constants $C_1$ and $C_2$ depend on the camera model as shown in the table below:

| Camera Model | $C_1$ | $C_2$ | Camera Model | $C_1$ | $C_2$ |
|---|---|---|---|---|---|
| slA640-74gm/gc | 22.66 µs | 1433.66 µs | slA1390-17gm/gc | 46.53 µs | 10244.54 µs |
| slA780-54gm/gc | 26.94 µs | 2308.54 µs | slA1400-17gm/gc | 46.53 µs | 9357.50 µs |

**Formula 2:**

Calculates the maximum frame rate based on the exposure time for the acquired frames:

$$\text{Max. Frames/s} = \frac{1}{\text{Exposure time in µs} + C_3}$$

Where the constant $C_3$ depends on the camera model as shown in the table below:

| Camera Model | $C_3$ | Camera Model | $C_3$ |
|---|---|---|---|
| slA640-74gm/gc | 84 µs | slA1390-17gm/gc | 177 µs |
| slA780-54gm/gc | 100 µs | slA1400-17gm/gc | 175 µs |

For more information about setting the exposure time, see Section 9.7 on page 121.

**Formula 3:**

Calculates the maximum frame rate based on the frame transmission time:

$$\text{Max. Frames/s} = \frac{\text{Device Current Throughput Parameter Value}}{\text{Payload Size Parameter Value}}$$

## Example

Assume that you are using an slA640-74gm camera set for an exposure time of 2000 µs and for 600 x 400 resolution. Also assume that you have checked the value of the Device Current Throughput parameter and the Payload Size parameters and found them to be 110000000 and 240000 respectively.

**Formula 1:**

$$\text{Max Frames/s} = \frac{1}{[(400 + 1) \times 22.66] + 1433.66}$$

Max Frames/s = 95.0 frames/s

**Formula 2:**

$$\text{Max Frames/s} = \frac{1}{2000\ \mu s + 84\ \mu s}$$

Max Frames/s = 479.8 frames/s

**Formula 3:**

$$\text{Max Frames/s} = \frac{110000000}{240000}$$

Max Frames/s = 458.3 frames/s

Formula one returns the lowest value. So in this case, the limiting factor is the sensor readout time, and the maximum allowed acquisition frame rate would be 95.0 frames per second.

# 10 Pixel Data Formats

By selecting a pixel data format, you determine the format (layout) of the image data transmitted by the camera. This section provides detailed information about the available pixel data formats.

## 10.1 Setting the Pixel Data Format

The setting for the camera's Pixel Format parameter determines the format of the pixel data that will be output from the camera. The available pixel formats depend on the camera model and whether the camera is monochrome or color. Table 11 lists the pixel formats available on each monochrome camera model and Table 12 lists the pixel formats available on each color camera model.

| Mono Camera Model | Mono 8 | Mono 16 | Mono 12 Packed | YUV 4:2:2 Packed | YUV 4:2:2 (YUYV) Packed |
|---|---|---|---|---|---|
| slA640-74 | • | • | • | • | • |
| slA780-54 | • | • | • | • | • |
| slA1390-17 | • | • | • | • | • |
| slA1400-17 | • | • | • | • | • |

Table 11: Pixel Formats Available on Monochrome Cameras ( • = format available)

| Color Camera Model | Mono 8 | Bayer BG 8 | Bayer BG 16 | Bayer BG 12 Packed | YUV 4:2:2 Packed | YUV 4:2:2 (YUYV) Packed |
|---|---|---|---|---|---|---|
| slA640-74 | • | • | • | • | • | • |
| slA780-54 | • | • | • | • | • | • |
| slA1390-17 | • | • | • | • | • | • |
| slA1400-17 | • | • | • | • | • | • |

Table 12: Pixel Formats Available on Color Cameras ( • = format available)

Details of the monochrome formats are described in Section 10.2 on page 151 and details of the color formats are described in Section 10.3 on page 157.

You can set the Pixel Format parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the parameter value:

```
Camera.PixelFormat.SetValue( PixelFormat_Mono8 );
Camera.PixelFormat.SetValue( PixelFormat_Mono12Packed );
Camera.PixelFormat.SetValue( PixelFormat_Mono16 );
Camera.PixelFormat.SetValue( PixelFormat_YUV422Packed );
Camera.PixelFormat.SetValue( PixelFormat_YUV422_YUYV_Packed );
Camera.PixelFormat.SetValue( PixelFormat_BayerBG8 );
Camera.PixelFormat.SetValue( PixelFormat_BayerBG16 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

# 10.2 Pixel Data Formats for Mono Cameras

## 10.2.1 Mono 8 Format (Equivalent to DCAM Mono 8)

When a monochrome camera is set for the Mono 8 pixel data format, it outputs 8 bits of brightness data per pixel.

The table below describes how the pixel data for a received frame will be ordered in the image buffer in your PC when the camera is set for Mono8 output.

The following standards are used in the table:

$P_0$ = the first pixel transmitted by the camera

$P_n$ = the last pixel transmitted by the camera

$B_0$ = the first byte in the buffer

$B_m$ = the last byte in the buffer

| Byte | Data |
|---|---|
| $B_0$ | Brightness value for $P_0$ |
| $B_1$ | Brightness value for $P_1$ |
| $B_2$ | Brightness value for $P_2$ |
| $B_3$ | Brightness value for $P_3$ |
| $B_4$ | Brightness value for $P_4$ |
| • | • |
| • | • |

| Byte | Data |
|---|---|
| • | • |
| • | • |
| $B_{m-4}$ | Brightness value for $P_{n-4}$ |
| $B_{m-3}$ | Brightness value for $P_{n-3}$ |
| $B_{m-2}$ | Brightness value for $P_{n-2}$ |
| $B_{m-1}$ | Brightness value for $P_{n-1}$ |
| $B_m$ | Brightness value for $P_n$ |

With the camera set for Mono8, the pixel data output is 8 bit data of the “unsigned char” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below.

| This Data Value (Hexadecimal) | Indicates This Signal Level (Decimal) |
|---|---|
| 0xFF | 255 |
| 0xFE | 254 |
| • | • |
| • | • |
| • | • |
| 0x01 | 1 |
| 0x00 | 0 |

## 10.2.2 Mono 16 Format (Equivalent to DCAM Mono 16)

When a monochrome camera is set for the Mono16 pixel data format, it outputs 16 bits of brightness data per pixel with 12 bits effective. The 12 bits of effective pixel data fill from the least significant bit. The four unused most significant bits are filled with zeros.

The table below describes how the pixel data for a received frame will be ordered in the image buffer in your PC when the camera is set for Mono16 output. Note that the data is placed in the image buffer in **little endian format**.

The following standards are used in the table:

$P_0$ = the first pixel transmitted by the camera

$P_n$ = the last pixel transmitted by the camera

$B_0$ = the first byte in the buffer

$B_m$ = the last byte in the buffer

| Byte | Data |
|---|---|
| $B_0$ | Low byte of brightness value for $P_0$ |
| $B_1$ | High byte of brightness value for $P_0$ |
| $B_2$ | Low byte of brightness value for $P_1$ |
| $B_3$ | High byte of brightness value for $P_1$ |
| $B_4$ | Low byte of brightness value for $P_2$ |
| $B_5$ | High byte of brightness value for $P_2$ |
| $B_6$ | Low byte of brightness value for $P_3$ |
| $B_7$ | High byte of brightness value for $P_3$ |
| $B_8$ | Low byte of brightness value for $P_4$ |
| $B_9$ | High byte of brightness value for $P_4$ |
| • | • |
| • | • |
| • | • |
| $B_{m-7}$ | Low byte of brightness value for $P_{n-3}$ |
| $B_{m-6}$ | High byte of brightness value for $P_{n-3}$ |
| $B_{m-5}$ | Low byte of brightness value for $P_{n-2}$ |
| $B_{m-4}$ | High byte of brightness value for $P_{n-2}$ |
| $B_{m-3}$ | Low byte of brightness value for $P_{n-1}$ |
| $B_{m-2}$ | High byte of brightness value for $P_{n-1}$ |
| $B_{m-1}$ | Low byte of brightness value for $P_n$ |
| $B_m$ | High byte of brightness value for $P_n$ |

When the camera is set for Mono 16, the pixel data output is 16 bit data of the “unsigned short (little endian)” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below. Note that for 16 bit data, you might expect a value range from 0x0000 to 0xFFFF. However, with the camera set for Mono16 only 12 bits of the 16 bits transmitted are effective. Therefore, the highest data value you will see is 0x0FFF indicating a signal level of 4095.

| This Data Value (Hexadecimal) | Indicates This Signal Level (Decimal) |
|---|---|
| 0x0FFF | 4095 |
| 0x0FFE | 4094 |
| • | • |
| • | • |
| • | • |
| 0x0001 | 1 |
| 0x0000 | 0 |

When a camera that is set for Mono 16 has only 12 bits effective, the leader of transmitted frames will indicate Mono 12 as the pixel format.

## 10.2.3 Mono 12 Packed Format

When a monochrome camera is set for the Mono 12 Packed pixel data format, it outputs 12 bits of brightness data per pixel. Every three bytes transmitted by the camera contain data for two pixels.

The table below describes how the pixel data for a received frame will be ordered in the image buffer in your PC when the camera is set for Mono 12 Packed output.

The following standards are used in the table:

$P_0$ = the first pixel transmitted by the camera

$P_n$ = the last pixel transmitted by the camera

$B_0$ = the first byte in the buffer

$B_m$ = the last byte in the buffer

| **Byte** | **Data** | |
|---|---|---|
| $B_0$ | $P_0$ bits 11 ... 4 | |
| $B_1$ | $P_1$ bits 3 ... 0 | $P_0$ bits 3 ... 0 |
| $B_2$ | $P_1$ bits 11 ... 4 | |
| $B_3$ | $P_2$ bits 11 ... 4 | |
| $B_4$ | $P_3$ bits 3 ... 0 | $P_2$ bits 3 ... 0 |
| $B_5$ | $P_3$ bits 11 ... 4 | |
| $B_6$ | $P_4$ bits 11 ... 4 | |
| $B_7$ | $P_5$ bits 3 ... 0 | $P_4$ bits 3 ... 0 |
| $B_8$ | $P_5$ bits 11 ... 4 | |
| $B_9$ | $P_6$ bits 11 ... 4 | |
| $B_{10}$ | $P_7$ bits 3 ... 0 | $P_6$ bits 3 ... 0 |
| $B_{11}$ | $P_7$ bits 11 ... 4 | |
| • | • | |
| • | • | • |
| • | • | |
| $B_{m-5}$ | $P_{n-3}$ bits 11 ... 4 | |
| $B_{m-4}$ | $P_{n-2}$ bits 3 ... 0 | $P_{n-3}$ bits 3 ... 0 |
| $B_{m-3}$ | $P_{n-2}$ bits 11 ... 4 | |
| $B_{m-2}$ | $P_{n-1}$ bits 11 ... 4 | |
| $B_{m-1}$ | $P_n$ bits 3 ... 0 | $P_{n-1}$ bits 3 ... 0 |
| $B_m$ | $P_n$ bits 11 ... 4 | |

When a monochrome camera is set for Mono 12 Packed, the pixel data output is 12 bit data of the “unsigned” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below.

| This Data Value (Hexadecimal) | Indicates This Signal Level (Decimal) |
|---|---|
| 0x0FFF | 4095 |
| 0x0FFE | 4094 |
| • | • |
| • | • |
| • | • |
| 0x0001 | 1 |
| 0x0000 | 0 |

## 10.2.4 YUV 4:2:2 Packed Format (Equivalent to DCAM YUV 4:2:2)

When a monochrome camera is set for the YUV 4:2:2 Packed pixel data format, the camera transmits Y, U, and V values in a fashion that mimics the output from a color camera set for YUV 4:2:2 Packed.

The Y value transmitted for each pixel is an actual 8 bit brightness value similar to the pixel data transmitted when a monochrome camera is set for Mono 8. The U and V values transmitted will always be zero. With this color coding, a Y value is transmitted for each pixel, but the U and V values are only transmitted for every second pixel.

The order of the pixel data for a received frame in the image buffer in your PC is similar to the order of YUV 4:2:2 Packed output from a color camera.

For more information about the YUV 4:2:2 Packed format on color cameras, see Section 10.3.5 on page 165.

## 10.2.5 YUV 4:2:2 (YUYV) Packed Format

When a monochrome camera is set for the YUV 4:2:2 (YUYV) Packed pixel data format, the camera transmits Y, U, and V values in a fashion that mimics the output from a color camera set for YUV 4:2:2 (YUYV) Packed.

The Y value transmitted for each pixel is an actual 8 bit brightness value similar to the pixel data transmitted when a monochrome camera is set for Mono 8. The U and V values transmitted will always be zero. With this color coding, a Y value is transmitted for each pixel, but the U and V values are only transmitted for every second pixel.

The order of the pixel data for a received frame in the image buffer in your PC is similar to the order of YUV 4:2:2 (YUYV) Packed output from a color camera.

For more information about the YUV 4:2:2 (YUYV) Packed format on color cameras, see Section 10.3.6 on page 168.

# 10.3 Pixel Data Output Formats for Color Cameras

## 10.3.1 The Bayer Color Filter

The sensor used in color models of the camera is equipped with an additive color separation filter known as a Bayer filter. The pixel data output formats available on color cameras are related to the Bayer pattern, so you need a basic knowledge of the Bayer filter to understand the pixel formats. With the Bayer filter, each individual pixel is covered by a micro-lens that allows light of only one color to strike the pixel. The pattern of the Bayer filter used on the camera is as shown in Figure 46 (the figure shows the "BG" filter alignment). As the figure illustrates, within each square of four pixels, one pixel sees only red light, one sees only blue light, and two pixels see only green light. (This combination mimics the human eye's sensitivity to color.)

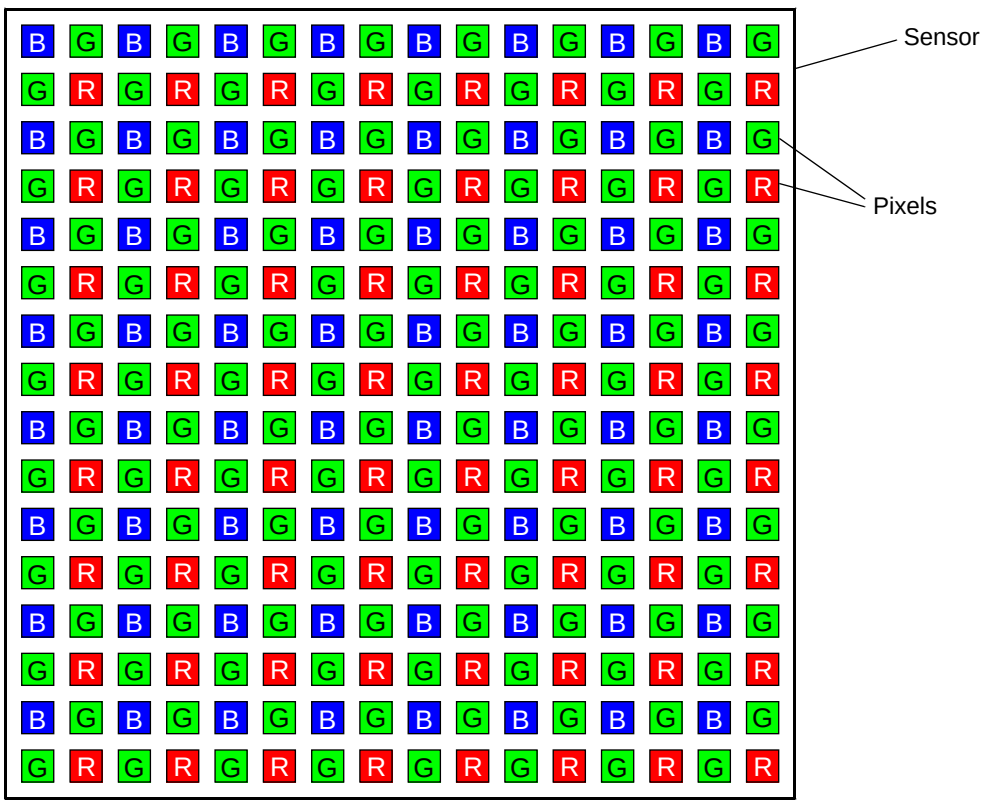



Fig. 46: Bayer Filter Pattern

#### 10.3.1.1 Color Filter Alignment

The alignment of the Bayer filter to the pixels in the images acquired by color cameras is Bayer BG for all camera models.

Bayer BG alignment means that pixel one and pixel two of the first line in each image transmitted will be blue and green respectively. And for the second line transmitted, pixel one and pixel two will be green and red respectively. Since the pattern of the Bayer filter is fixed, you can use this information to determine the color of all of the other pixels in the image.

Because the size and position of the area of interest on color cameras must be adjusted in increments of 2, the color filter alignment will remain the same regardless of the camera's area of interest (AOI) settings.

The Pixel Color Filter parameter indicates the alignment of the camera's Bayer filter to the pixels in the images captured by a color camera. You can tell how the current AOI is aligned to the Bayer filter by reading the value of the Pixel Color Filter parameter.

For more information about the camera's AOI feature, see Section 11.6 on page 185.

## 10.3.2 Bayer BG 8 Format (Equivalent to DCAM Raw 8)

When a color camera is set for the Bayer BG 8 pixel data format, it outputs 8 bits of data per pixel and the pixel data is not processed or interpolated in any way. So, for each pixel covered with a red lens, you get 8 bits of red data. For each pixel covered with a green lens, you get 8 bits of green data. And for each pixel covered with a blue lens, you get 8 bits of blue data. (This type of pixel data is sometimes referred to as "raw" output.)

The "BG" in the name Bayer BG 8 refers to the alignment of the colors in the Bayer filter to the pixels in the acquired images. For even rows in the images, pixel one will be blue, pixel two will be green, pixel three will be blue, pixel four will be green, etc. For odd rows in the images, pixel one will be green, pixel two will be red, pixel three will be green, pixel four will be red, etc.

For more information about the Bayer filter, see Section 10.3.1 on page 157.

The tables below describe how the data for the even rows and for the odd rows of a received frame will be ordered in the image buffer in your PC when the camera is set for Bayer BG 8 output.

The following standards are used in the tables:

$P_0$ = the first pixel transmitted by the camera for a row

$P_n$ = the last pixel transmitted by the camera for a row

$B_0$ = the first byte of data for a row

$B_m$ = the last byte of data for a row

| **Even Rows** | |
|---|---|
| **Byte** | **Data** |
| $B_0$ | Blue value for $P_0$ |
| $B_1$ | Green value for $P_1$ |
| $B_2$ | Blue value for $P_2$ |
| $B_3$ | Green value for $P_3$ |
| $B_4$ | Blue value for $P_4$ |
| $B_5$ | Green value for $P_5$ |
| [2] | • |
| [2] | • |
| [2] | • |
| $B_{m-5}$ | Blue value for $P_{n-5}$ |
| $B_{m-4}$ | Green value for $P_{n-4}$ |
| $B_{m-3}$ | Blue value for $P_{n-3}$ |
| $B_{m-2}$ | Green value for $P_{n-2}$ |
| $B_{m-1}$ | Blue value for $P_{n-1}$ |
| $B_m$ | Green value for $P_n$ |

| **Odd Rows** | |
|---|---|
| **Byte** | **Data** |
| $B_0$ | Green value for $P_0$ |
| $B_1$ | Red value for $P_1$ |
| $B_2$ | Green value for $P_2$ |
| $B_3$ | Red value for $P_3$ |
| $B_4$ | Green value for $P_4$ |
| $B_5$ | Red value for $P_5$ |
| [2] | • |
| [2] | • |
| [2] | • |
| $B_{m-5}$ | Green value for $P_{n-5}$ |
| $B_{m-4}$ | Red value for $P_{n-4}$ |
| $B_{m-3}$ | Green value for $P_{n-3}$ |
| $B_{m-2}$ | Red value for $P_{n-2}$ |
| $B_{m-1}$ | Green value for $P_{n-1}$ |
| $B_m$ | Red value for $P_n$ |

With the camera set for Bayer BG 8, the pixel data output is 8 bit data of the “unsigned char” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below.

| This Data Value (Hexadecimal) | Indicates This Signal Level (Decimal) |
|---|---|
| 0xFF | 255 |
| 0xFE | 254 |
| • | • |
| • | • |
| • | • |
| 0x01 | 1 |
| 0x00 | 0 |

## 10.3.3 Bayer BG 16 Format (Equivalent to DCAM Raw 16)

When a color camera is set for the Bayer BG 16 pixel data format, it outputs 16 bits of data per pixel with 12 bits effective. The 12 bits of effective pixel data fill from the least significant bit. The four unused most significant bits are filled with zeros.

With the Bayer BG 16 the pixel data is not processed or interpolated in any way. So, for each pixel covered with a red lens, you get 12 effective bits of red data. For each pixel covered with a green lens, you get 12 effective bits of green data. And for each pixel covered with a blue lens, you get 12 effective bits of blue data. (This type of pixel data is sometimes referred to as "raw" output.)

The "BG" in the name Bayer BG 16 refers to the alignment of the colors in the Bayer filter to the pixels in the acquired images. For even lines in the images, pixel one will be blue, pixel two will be green, pixel three will be blue, pixel four will be green, etc. For odd lines in the images, pixel one will be green, pixel two will be red, pixel three will be green, pixel four will be red, etc.

For more information about the Bayer filter, see Section 10.3.1 on page 157.

The tables below describe how the data for the even lines and for the odd lines of a received frame will be ordered in the image buffer in your PC when the camera is set for Bayer BG 16 output. Note that the data is placed in the image buffer in **little endian format**.

The following standards are used in the tables:

$P_0$ = the first pixel transmitted by the camera for a line

$P_n$ = the last pixel transmitted by the camera for a line

$B_0$ = the first byte of data for a line

$B_m$ = the last byte of data for a line

| **Even Lines** | |
|---|---|
| **Byte** | **Data** |
| $B_0$ | Low byte of blue value for $P_0$ |
| $B_1$ | High byte of blue value for $P_0$ |
| $B_2$ | Low byte of green value for $P_1$ |
| $B_3$ | High byte of green value for $P_1$ |
| $B_4$ | Low byte of blue value for $P_2$ |
| $B_5$ | High byte of blue value for $P_2$ |
| $B_6$ | Low byte of green value for $P_3$ |
| $B_7$ | High byte of green value for $P_3$ |
| • | • |
| • | • |
| • | • |
| $B_{m-7}$ | Low byte of blue value for $P_{n-3}$ |
| $B_{m-6}$ | High byte of blue value for $P_{n-3}$ |

| **Odd Lines** | |
|---|---|
| **Byte** | **Data** |
| $B_0$ | Low byte of green value for $P_0$ |
| $B_1$ | High byte of green value for $P_0$ |
| $B_2$ | Low byte of red value for $P_1$ |
| $B_3$ | High byte of red value for $P_1$ |
| $B_4$ | Low byte of green value for $P_2$ |
| $B_5$ | High byte of green value for $P_2$ |
| $B_6$ | Low byte of red value for $P_3$ |
| $B_7$ | High byte of red value for $P_3$ |
| • | • |
| • | • |
| • | • |
| $B_{m-7}$ | Low byte of green value for $P_{n-3}$ |
| $B_{m-6}$ | High byte of green value for $P_{n-3}$ |

| | |
|---|---|
| $B_{m-5}$ | Low byte of green value for $P_{n-2}$ |
| $B_{m-4}$ | High byte of green value for $P_{n-2}$ |
| $B_{m-3}$ | Low byte of blue value for $P_{n-1}$ |
| $B_{m-2}$ | High byte of blue value for $P_{n-1}$ |
| $B_{m-1}$ | Low byte of green value for $P_n$ |
| $B_m$ | High byte of green value for $P_n$ |

| | |
|---|---|
| $B_{m-5}$ | Low byte of red value for $P_{n-2}$ |
| $B_{m-4}$ | High byte of red value for $P_{n-2}$ |
| $B_{m-3}$ | Low byte of green value for $P_{n-1}$ |
| $B_{m-2}$ | High byte of green value for $P_{n-1}$ |
| $B_{m-1}$ | Low byte of red value for $P_n$ |
| $B_m$ | High byte of red value for $P_n$ |

When the camera is set for Bayer BG 16, the pixel data output is 16 bit data of the “unsigned short (little endian)” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below. Note that for 16 bit data, you might expect a value range from 0x0000 to 0xFFFF. However, with the camera set for Bayer BG 16 only 12 bits of the 16 bits transmitted are effective. Therefore, the highest data value you will see is 0x0FFF indicating a signal level of 4095.

| **This Data Value (Hexadecimal)** | **Indicates This Signal Level (Decimal)** |
|---|---|
| 0x0FFF | 4095 |
| 0x0FFE | 4094 |
| • | • |
| • | • |
| • | • |
| 0x0001 | 1 |
| 0x0000 | 0 |

When a camera that is set for Bayer BG 16 has only 12 bits effective, the leader of transmitted frames will indicate Bayer BG 12 as the pixel format.

## 10.3.4 Bayer BG 12 Packed Format

When a color camera is set for the Bayer BG 12 Packed pixel data format, it outputs 12 bits of data per pixel. Every three bytes transmitted by the camera contain data for two pixels.

With the Bayer BG 12 Packed coding, the pixel data is not processed or interpolated in any way. So, for each pixel covered with a red lens in the sensor's Bayer filter, you get 12 bits of red data. For each pixel covered with a green lens in the filter, you get 12 bits of green data. And for each pixel covered with a blue lens in the filter, you get 12 bits of blue data. (This type of pixel data is sometimes referred to as "raw" output.)

For more information about the Bayer filter, see Section 10.3.1 on page 157.

The tables below describe how the data for the even rows and for the odd rows of a received frame will be ordered in the image buffer in your PC when the camera is set for Bayer BG12 Packed output.

The following standards are used in the tables:

$P_0$ = the first pixel transmitted by the camera for a row

$P_n$ = the last pixel transmitted by the camera for a row

$B_0$ = the first byte of data for a row

$B_m$ = the last byte of data for a row

| **Even Rows** | | |
|---|---|---|
| **Byte** | **Data** | |
| $B_0$ | Blue value for $P_0$ bits 11 ... 4 | |
| $B_1$ | Green value for $P_1$ bits 3 ... 0 | Blue value for $P_0$ bits 3 ... 0 |
| $B_2$ | Green value for $P_1$ bits 11 ... 4 | |
| $B_3$ | Blue value for $P_2$ bits 11 ... 4 | |
| $B_4$ | Green value for $P_3$ bits 3 ... 0 | Blue value for $P_2$ bits 3 ... 0 |
| $B_5$ | Green value for $P_3$ bits 11 ... 4 | |
| $B_6$ | Blue value for $P_4$ bits 11 ... 4 | |
| $B_7$ | Green value for $P_5$ bits 3 ... 0 | Blue value for $P_4$ bits 3 ... 0 |
| $B_8$ | Green value for $P_5$ bits 11 ... 4 | |
| • | • | |
| • | • | • |
| • | • | |
| $B_{m-5}$ | Blue value for $P_{n-3}$ bits 11 ... 4 | |
| $B_{m-4}$ | Green value for $P_{n-2}$ bits 3 ... 0 | Blue value for $P_{n-3}$ bits 3 ... 0 |
| $B_{m-3}$ | Green value for $P_{n-2}$ bits 11 ... 4 | |
| $B_{m-2}$ | Blue value for $P_{n-1}$ bits 11 ... 4 | |
| $B_{m-1}$ | Green value for $P_n$ bits 3 ... 0 | Blue value for $P_{n-1}$ bits 3 ... 0 |
| $B_m$ | Green value for $P_n$ bits 11 ... 4 | |

| Odd Rows | | |
|---|---|---|
| **Byte** | **Data** | |
| $B_0$ | Green value for $P_0$ bits 11 ... 4 | |
| $B_1$ | Red value for $P_1$ bits 3 ... 0 | Green value for $P_0$ bits 3 ... 0 |
| $B_2$ | Red value for $P_1$ bits 11 ... 4 | |
| $B_3$ | Green value for $P_2$ bits 11 ... 4 | |
| $B_4$ | Red value for $P_3$ bits 3 ... 0 | Green value for $P_2$ bits 3 ... 0 |
| $B_5$ | Red value for $P_3$ bits 11 ... 4 | |
| $B_6$ | Green value for $P_4$ bits 11 ... 4 | |
| $B_7$ | Red value for $P_5$ bits 3 ... 0 | Green value for $P_4$ bits 3 ... 0 |
| $B_8$ | Red value for $P_5$ bits 11 ... 4 | |
| • | • | |
| • | • | • |
| • | • | |
| • | • | |
| • | • | • |
| • | • | |
| $B_{m-5}$ | Green value for $P_{n-3}$ bits 11 ... 4 | |
| $B_{m-4}$ | Red value for $P_{n-2}$ bits 3 ... 0 | Green value for $P_{n-3}$ bits 3 ... 0 |
| $B_{m-3}$ | Red value for $P_{n-2}$ bits 11 ... 4 | |
| $B_{m-2}$ | Green value for $P_{n-1}$ bits 11 ... 4 | |
| $B_{m-1}$ | Red value for $P_n$ bits 3 ... 0 | Green value for $P_{n-1}$ bits 3 ... 0 |
| $B_m$ | Red value for $P_n$ bits 11 ... 4 | |

When a color camera is set for Bayer BG 12 Packed, the pixel data output is 12 bit data of the “unsigned” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below.

| **This Data Value (Hexadecimal)** | **Indicates This Signal Level (Decimal)** |
|---|---|
| 0x0FFF | 4095 |
| 0x0FFE | 4094 |
| • | • |
| • | • |
| • | • |
| 0x0001 | 1 |
| 0x0000 | 0 |

## 10.3.5 YUV 4:2:2 Packed Format (Equivalent to DCAM YUV 4:2:2)

When a color camera is set for the YUV 422 Packed pixel data format, each pixel in the captured image goes through a two step conversion process as it exits the sensor and passes through the camera's electronics. This process yields Y, U, and V color information for each pixel.

In the first step of the process, an interpolation algorithm is performed to get full RGB data for each pixel. This is required because color cameras use a Bayer filter on the sensor and each individual pixel gathers information for only one color.

For more information on the Bayer filter, see Section 10.3.1 on page 157.

The second step of the process is to convert the RGB information to the YUV color model. The conversion algorithm uses the following formulas:

$Y = 0.30\ R + 0.59\ G + 0.11\ B$

$U = -0.17\ R - 0.33\ G + 0.50\ B$

$V = 0.50\ R - 0.41\ G - 0.09\ B$

Once the conversion to a YUV color model is complete, the pixel data is transmitted to the host PC.

The values for U and for V normally range from -128 to +127. Because the camera transfers U values and V values with unsigned integers, 128 is added to each U value and to each V value before the values are transferred from the camera. This process allows the values to be transferred on a scale that ranges from 0 to 255.

The table below describes how the pixel data for a received frame will be ordered in the image buffer in your PC when the camera is set for YUV 4:2:2 Packed output.

The following standards are used in the table:

$P_0$ = the first pixel transmitted by the camera

$P_n$ = the last pixel transmitted by the camera

$B_0$ = the first byte in the buffer

$B_m$ = the last byte in the buffer

| Byte | Data |
|---|---|
| $B_0$ | U value for $P_0$ |
| $B_1$ | Y value for $P_0$ |
| $B_2$ | V Value for $P_0$ |
| $B_3$ | Y value for $P_1$ |

| | |
|---|---|
| $B_4$ | U value for $P_2$ |
| $B_5$ | Y value for $P_2$ |
| $B_6$ | V Value for $P_2$ |
| $B_7$ | Y value for $P_3$ |
| $B_8$ | U value for $P_4$ |
| $B_9$ | Y value for $P_4$ |
| $B_{10}$ | V Value for $P_4$ |
| $B_{11}$ | Y value for $P_5$ |
| • | • |
| • | • |
| • | • |
| $B_{m-7}$ | U value for $P_{n-3}$ |
| $B_{m-6}$ | Y value for $P_{n-3}$ |
| $B_{m-5}$ | V Value for $P_{n-3}$ |
| $B_{m-4}$ | Y value for $P_{n-2}$ |
| $B_{m-3}$ | U value for $P_{n-1}$ |
| $B_{m-2}$ | Y value for $P_{n-1}$ |
| $B_{m-1}$ | V Value for $P_{n-1}$ |
| $B_m$ | Y value for $P_n$ |

When the camera is set for YUV 4:2:2 Packed output, the pixel data output for the Y component is 8 bit data of the “unsigned char” type. The range of data values for the Y component and the corresponding indicated signal levels are shown below.

| **This Data Value (Hexadecimal)** | **Indicates This Signal Level (Decimal)** |
|---|---|
| 0xFF | 255 |
| 0xFE | 254 |
| • | • |
| • | • |
| • | • |
| 0x01 | 1 |
| 0x00 | 0 |

The pixel data output for the U component or the V component is 8 bit data of the “straight binary” type. The range of data values for a U or a V component and the corresponding indicated signal levels are shown below.

| This Data Value (Hexadecimal) | Indicates This Signal Level (Decimal) |
|---|---|
| 0xFF | 127 |
| 0xFE | 126 |
| • | • |
| • | • |
| • | • |
| 0x81 | 1 |
| 0x80 | 0 |
| 0x7F | -1 |
| • | • |
| • | • |
| • | • |
| 0x01 | -127 |
| 0x00 | -128 |

The signal level of a U component or a V component can range from -128 to +127 (decimal). Notice that the data values have been arranged to represent the full signal level range.

## 10.3.6 YUV 4:2:2 (YUYV) Packed Format

On color cameras, the YUV 4:2:2 (YUYV) packed pixel data format is similar to the YUV 4:2:2 pixel format described in the previous section. The only difference is the order of the bytes transmitted to the host PC. With the YUV 4:2:2 format, the bytes are ordered as specified in the DCAM standard issued by the 1394 Trade Association. With the YUV 4:2:2 (YUYV) format, the bytes are ordered to emulate the ordering normally associated with analog frame grabbers and Windows® frame buffers.

The table below describes how the pixel data for a received frame will be ordered in the image buffer in your PC when the camera is set for YUV 4:2:2 (YUYV) output.

With this format, the Y component is transmitted for each pixel, but the U and V components are only transmitted for every second pixel.

The following standards are used in the table:

$P_0$ = the first pixel transmitted by the camera

$P_n$ = the last pixel transmitted by the camera

$B_0$ = the first byte in the buffer

$B_m$ = the last byte in the buffer

| Byte | Data |
|---|---|
| $B_0$ | Y value for $P_0$ |
| $B_1$ | U value for $P_0$ |
| $B_2$ | Y value for $P_1$ |
| $B_3$ | V value for $P_0$ |
| $B_4$ | Y value for $P_2$ |
| $B_5$ | U value for $P_2$ |
| $B_6$ | Y value for $P_3$ |
| $B_7$ | V value for $P_2$ |
| $B_8$ | Y value for $P_4$ |
| $B_9$ | U value for $P_4$ |
| $B_{10}$ | Y value for $P_5$ |
| $B_{11}$ | V value for $P_4$ |
| • | • |
| • | • |
| • | • |
| $B_{m-7}$ | Y value for $P_{n-3}$ |
| $B_{m-6}$ | U value for $P_{n-3}$ |
| $B_{m-5}$ | Y value for $P_{n-2}$ |
| $B_{m-4}$ | V value for $P_{n-3}$ |
| $B_{m-3}$ | Y value for $P_{n-1}$ |
| $B_{m-2}$ | U value for $P_{n-1}$ |
| $B_{m-1}$ | Y value for $P_n$ |
| $B_m$ | V value for $P_{n-1}$ |

When a color camera is set for YUV 4:2:2 (YUYV) output, the pixel data output for the Y component is 8 bit data of the “unsigned char” type. The range of data values for the Y component and the corresponding indicated signal levels are shown below.

| This Data Value (Hexadecimal) | Indicates This Signal Level (Decimal) |
|---|---|
| 0xFF | 255 |
| 0xFE | 254 |
| • | • |
| • | • |
| • | • |
| 0x01 | 1 |
| 0x00 | 0 |

The pixel data output for the U component or the V component is 8 bit data of the “straight binary” type. The range of data values for a U or a V component and the corresponding indicated signal levels are shown below.

| This Data Value (Hexadecimal) | Indicates This Signal Level (Decimal) |
|---|---|
| 0xFF | 127 |
| 0xFE | 126 |
| • | • |
| • | • |
| • | • |
| 0x81 | 1 |
| 0x80 | 0 |
| 0x7F | -1 |
| • | • |
| • | • |
| • | • |
| 0x01 | -127 |
| 0x00 | -128 |

The signal level of a U component or a V component can range from -128 to +127 (decimal). Notice that the data values have been arranged to represent the full signal level range.

## 10.3.7 Mono 8 Format (Equivalent to DCAM Mono 8)

When a color camera is set for the Mono 8 pixel data format, the pixel values in each captured image are first interpolated and converted to the YUV color model as described for the YUV 4:2:2 Packed format. The camera then transmits the 8 bit Y value for each pixel to the host PC. In the YUV color model, the Y component for each pixel represents a brightness value. This brightness value can be considered as equivalent to the value that would be sent from a pixel in a monochrome camera. So in essence, when a color camera is set for Mono 8, it outputs an 8 bit monochrome image. (This type of output is sometimes referred to as "Y Mono 8".)

The table below describes how the pixel data for a received frame will be ordered in the image buffer in your PC when a color camera is set for Mono 8 output.

The following standards are used in the table:

$P_0$ = the first pixel transmitted by the camera

$P_n$ = the last pixel transmitted by the camera

$B_0$ = the first byte in the buffer

$B_m$ = the last byte in the buffer

| Byte | Data |
|---|---|
| $B_0$ | Y value for $P_0$ |
| $B_1$ | Y value for $P_1$ |
| $B_2$ | Y value for $P_2$ |
| $B_3$ | Y value for $P_3$ |
| $B_4$ | Y value for $P_4$ |
| $B_5$ | Y value for $P_5$ |
| $B_6$ | Y value for $P_6$ |
| $B_7$ | Y value for $P_7$ |
| • | • |
| • | • |
| • | • |
| $B_{m-3}$ | Y value for $P_{n-3}$ |
| $B_{m-2}$ | Y value for $P_{n-2}$ |
| $B_{m-1}$ | Y value for $P_{n-1}$ |
| $B_m$ | Y value for $P_n$ |

With the camera set for Mono 8, the pixel data output is 8 bit data of the “unsigned char” type. The available range of data values and the corresponding indicated signal levels are as shown in the table below.

| This Data Value (Hexadecimal) | Indicates This Signal Level (Decimal) |
|---|---|
| 0xFF | 255 |
| 0xFE | 254 |
| • | • |
| • | • |
| • | • |
| 0x01 | 1 |
| 0x00 | 0 |

# 10.4 Pixel Transmission Sequence

For each captured image, pixel data is transmitted from the camera in the following sequence:

| | | | | | | |
|---|---|---|---|---|---|---|
| $Row_0 Col_0$, | $Row_0 Col_1$, | $Row_0 Col_2$ | .. .. | $Row_0 Col_{m-2}$, | $Row_0 Col_{m-1}$, | $Row_0 Col_m$ |
| $Row_1 Col_0$, | $Row_1 Col_1$, | $Row_1 Col_2$ | .. .. | $Row_1 Col_{m-2}$, | $Row_1 Col_{m-1}$, | $Row_1 Col_m$ |
| $Row_2 Col_0$, | $Row_2 Col_1$, | $Row_2 Col_2$ | .. .. | $Row_2 Col_{m-2}$, | $Row_2 Col_{m-1}$, | $Row_2 Col_m$ |
| : | : | : | | : | : | : |
| : | : | : | | : | : | : |
| $Row_{n-2} Col_0$, | $Row_{n-2} Col_1$, | $Row_{n-2} Col_2$ | .. .. | $Row_{n-2} Col_{m-2}$, | $Row_{n-2} Col_{m-1}$, | $Row_{n-2} Col_m$ |
| $Row_{n-1} Col_0$, | $Row_{n-1} Col_1$, | $Row_{n-1} Col_2$ | .. .. | $Row_{n-1} Col_{m-2}$, | $Row_{n-1} Col_{m-1}$, | $Row_{n-1} Col_m$ |
| $Row_n Col_0$, | $Row_n Col_1$, | $Row_n Col_2$ | .. .. | $Row_n Col_{m-2}$, | $Row_n Col_{m-1}$, | $Row_n Col_m$ |

Where $Row_0 Col_0$ is the upper left corner of the sensor

The columns are numbered 0 through m from the left side to the right side of the sensor

The rows are numbered 0 through n from the top to the bottom of the sensor

The sequence assumes that the camera is set for full resolution.

# 11 Standard Features

This chapter provides detailed information about the standard features available on each camera. It also includes an explanation of their operation and the parameters associated with each feature.

## 11.1 Gain

The camera's gain setting is adjustable. As shown in Figure 47, increasing the gain increases the slope of the response curve for the camera. This results in a higher gray value output from the camera for a given amount of output from the imaging sensor. Decreasing the gain decreases the slope of the response curve and results in a lower gray value for a given amount of sensor output.

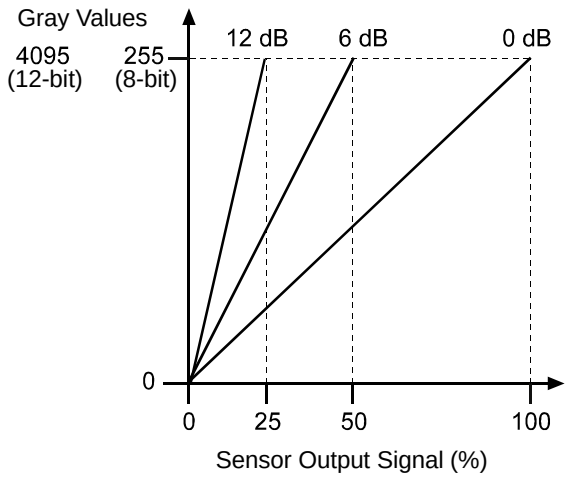



Fig. 47: Gain in dB

Increasing the gain is useful when at your brightest exposure, a gray value lower than 255 (in modes that output 8 bits per pixel) or 4095 (in modes that output 12 bits per pixels) is reached. For example, if you found that at your brightest exposure the gray values output by the camera were no higher than 127 (in an 8 bit mode), you could increase the gain to 6 dB (an amplification factor of 2) and thus reach gray values of 254.

## Setting the Gain

The camera's gain is determined by the value of the Gain Raw parameter. Gain Raw is adjusted on a decimal scale. The minimum decimal setting varies depending on the camera model (see Table 13). The maximum setting depends on whether the camera is set for a pixel data format that yields 8 bit effective pixel depth (Mono 8, Bayer BG 8, YUV 4:2:2 Packed, YUV 4:2:2 (YUYV) Packed) or yields an effective pixel depth of 12 bits per pixel (Mono 16, Mono 12 Packed, Bayer BG 16, Bayer BG 12 Packed).

| Camera Model | Min Setting | Max Setting (8 bit depth) | Max Setting (16 bit depth) |
|---|---|---|---|
| slA640-74 | 280 | 1023 | 511 |
| slA780-54 | 350 | 1023 | 511 |
| slA1390-17 | 360 | 1023 | 511 |
| slA1400-17 | 192 | 1023 | 511 |

Table 13: Minimum and Maximum Allowed Gain Raw Settings

To set the Gain Raw parameter value:

- Set the Gain Selector to Gain All.
- Set the Gain Raw parameter to your desired value.

You can set the Gain Selector and the Gain Raw parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.GainSelector.SetValue( GainSelector_All );
Camera.GainRaw.SetValue( 400 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

If you know the current decimal setting for the gain raw, you can use the formulas below to calculate the dB of gain that will result from that setting.

**Formulas:**

For gain raw settings from 110 to 511:

$$\text{Gain}_{dB} = 20 \times \log_{10}\left(\frac{658 + \text{Gain Raw Setting}}{658 - \text{Gain Raw Setting}}\right) - G_c$$

For gain raw settings from 512 to 1023:

$$Gain_{dB} = (0.0354 \times \text{Gain Raw Setting}) - G_c$$

Where:

$$G_c = 20 \times \log_{10}\left(\frac{658 + \text{Min Gain Raw Setting}}{658 - \text{Min Gain Raw Setting}}\right)$$

**Example:**

Assume that you are working with a monochrome slA1400-17 camera that has a gain raw setting of 500. Calculating the gain is a two step process:

Step 1:

$$G_c = 20 \times \log_{10}\left(\frac{658 + 192}{658 - 192}\right)$$

$$G_c = 5.22 \text{ dB}$$

Step 2:

$$Gain_{dB} = 20 \times \log_{10}\left(\frac{658 + 500}{658 - 500}\right) - 5.22 \text{ dB}$$

$$Gain_{dB} = 12.1 \text{ dB}$$

Table 14 shows the minimum and maximum gain in dB for each camera model.

| Camera Model | dB Gain at Min Setting | dB Gain at Max Setting (8 bit depth) | dB Gain at Max Setting (16 bit depth) |
|---|---|---|---|
| slA640-74 | 0 | 28.3 | 10.1 |
| slA780-54 | 0 | 25.9 | 7.7 |
| slA1390-17 | 0 | 25.5 | 7.3 |
| slA1400-17 | 0 | 31.0 | 12.8 |

Table 14: Minimum and Maximum dB of Gain

# 11.2 Black Level

Adjusting the camera's black level will result in an offset to the pixel values output by the camera. Increasing the black level setting will result in a positive offset in the digital values output for the pixels. Decreasing the black level setting will result in a negative offset in the digital values output for the pixels.

### Effect on All Camera Models

If the camera is set for a pixel data format that yields 8 bit effective pixel depth (Mono 8, Bayer BG 8, YUV 4:2:2 Packed, YUV 4:2:2 (YUYV) Packed), an increase of 16 in the black level parameter setting will result in a positive offset of 1 in the digital values output for the pixels. And a decrease of 16 in the setting will result in a negative offset of 1 in the digital values output for the pixels.

If the camera is set for a pixel data format that yields an effective pixel depth of 12 bits per pixel (Mono 16, Mono 12 Packed, Bayer BG 16, Bayer BG 12 Packed), an increase of 1 in the black level parameter setting will result in a positive offset of 1 in the digital values output for the pixels. A decrease of 1 in the setting will result in a negative offset of 1 in the digital values output for the pixels.

## Setting the Black Level

The black level can be adjusted by changing the value of the Black Level Raw parameter. The Black Level Raw parameter value can range from 0 to 255 on all camera models.

To set the Black Level Raw parameter value:

- Set the Black Level Selector to Black Level All.
- Set the Black Level Raw parameter to your desired value.

You can set the Black Level Selector and the Black Level Raw parameter value from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.BlackLevelSelector.SetValue ( BlackLevelSelector_All );
Camera.BlackLevelRaw.SetValue( 32 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

# 11.3 White Balance (on Color Models)

The white balance feature lets you adjust the balance of red, green, and blue such that white objects in the camera's field of view appear white in the acquired images.

## Setting the White Balance

With the white balancing scheme used on these cameras, the red intensity, green intensity, and blue intensity can be individually adjusted. For each color, a Balance Ratio parameter is used to set the intensity of the color. If the Balance Ratio parameter for a color is set to a value of 1, the intensity of the color will be unaffected by the white balance mechanism. If the ratio is set to a value lower than 1, the intensity of the color will be reduced. If the ratio is set to a value greater than 1, the intensity of the color will be increased. The increase or decrease in intensity is proportional. For example, if the balance ratio for a color is set to 1.2, the intensity of that color will be increased by 20 %.

The balance ratio value can range from 0.00 to 3.98. But you should be aware that if you set the balance ratio for a color to a value lower than 1, this will not only decrease the intensity of that color relative to the other two colors, but will also decrease the maximum intensity that the color can achieve. For this reason, we don't normally recommend setting a balance ratio less than 1 unless you want to correct for the strong predominance of one color.

To set the Balance Ratio parameter for a color:

- Set the Balance Ratio Selector to red, green, or blue.
- Set the Balance Ratio Abs parameter to the desired value for the selected color.

You can set the Balance Ratio Selector and the Balance Ratio Abs parameter value from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
Camera.BalanceRatioSelector.SetValue( BalanceRatioSelector_Green );
Camera.BalanceRatioAbs.SetValue( 1.20 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

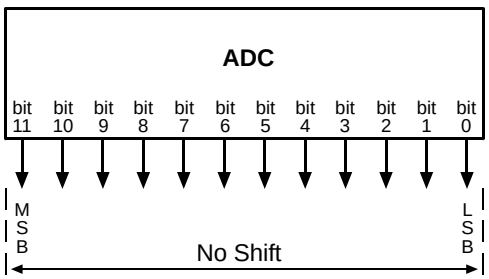
# 11.4 Digital Shift

The digital shift feature lets you change the group of bits that is output from the ADC in the camera. Using the digital shift feature will effectively multiply the output of the camera by 2 times, 4 times, 8 times, or 16 times. The next two sections describe how the digital shift feature works when the camera is set for a 12 bit pixel format and when it is set for a 8 bit pixel format. There is also a section describing precautions that you must observe when using the digital shift feature and a section that describes enabling and setting the digital shift feature.

## 11.4.1 Digital Shift with 12 Bit Pixel Formats

### No Shift

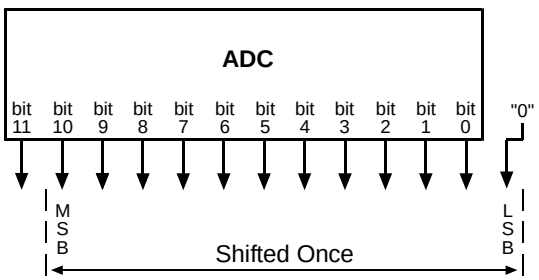
As mentioned in the Functional Description section of this manual, the camera uses a 12 bit ADC to digitize the output from the imaging sensor. When the camera is set for a pixel format that outputs pixel data at 12 bit effective depth, by default, the camera transmits the 12 bits that are output from the ADC.




### Shift by 1

When the camera is set to shift by 1, the output from the camera will include bit 10 through bit 0 from the ADC along with a zero as an LSB.

The result of shifting once is that the output of the camera is effectively multiplied by 2. For example, assume that the camera is set for no shift, that it is viewing a uniform white target, and that under these conditions the reading for the brightest pixel is 100. If you changed the digital shift setting to shift by 1, the reading would increase to 200.




When the camera is set to shift by 1, the least significant bit output from the camera for each pixel value will be 0. This means that no odd gray values can be output and that the gray value scale will only include values of 2, 4, 6, 8, 10, and so on. This absence of some gray values is commonly referred to as "missing codes".

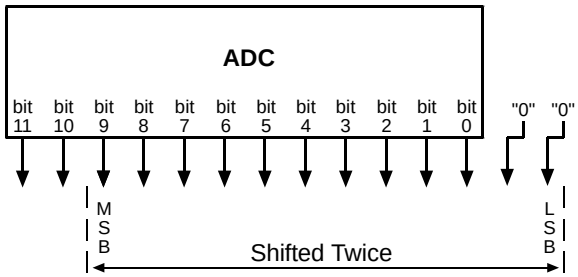
If the pixel values being output by the camera's sensor are high enough to set bit 11 to 1, we recommend not using shift by 1. If you do nonetheless, all bits output from the camera will automatically be set to 1. Therefore, you should only use the shift by 1 setting when your pixel readings with a 12 bit pixel format selected and with digital shift disabled are all less than 2048.

### Shift by 2

When the camera is set to shift by 2, the output from the camera will include bit 9 through bit 0 from the ADC along with 2 zeros as LSBs.

The result of shifting twice is that the output of the camera is effectively multiplied by 4.

When the camera is set to shift by 2, the 2 least significant bits output from the camera for each pixel value will be 0. This means that the gray value scale will only include every 4th value, for example, 4, 8, 16, 20, and so on.



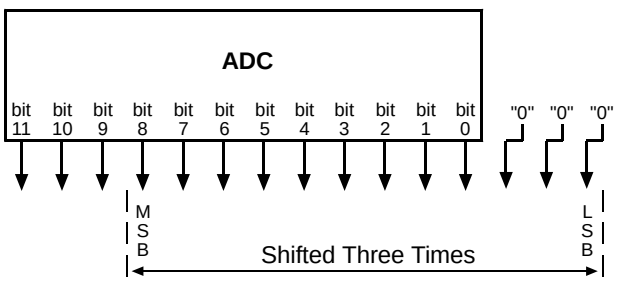

If the pixel values being output by the camera's sensor are high enough to set bit 10 or bit 11 to 1, we recommend not using shift by 2. If you do nonetheless, all bits output from the camera will automatically be set to 1. Therefore, you should only use the shift by 2 setting when your pixel readings with a 12 bit pixel format selected and with digital shift disabled are all less than 1024.

### Shift By 3

When the camera is set to shift by 3, the output from the camera will include bit 8 through bit 0 from the ADC along with 3 zeros as LSBs.

The result of shifting 3 times is that the output of the camera is effectively multiplied by 8.

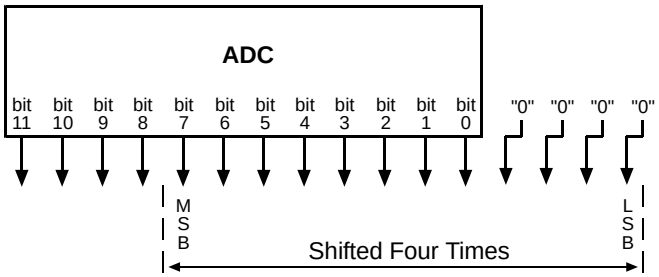
When the camera is set to shift by 3, the 3 least significant bits output from the camera for each pixel value will be 0. This means that the gray value scale will only include every 8th gray value, for example, 8, 16, 24, 32, and so on.




If the pixel values being output by the camera's sensor are high enough to set bit 9, bit 10, or bit 11 to 1, we recommend not using shift by 3. If you do nonetheless, all bits output from the camera will automatically be set to 1. Therefore, you should only use the shift by 3 setting when your pixel readings with a 12 bit pixel format selected and with digital shift disabled are all less than 512.

### Shift By 4

When the camera is set to shift by 4, the output from the camera will include bit 7 through bit 0 from the ADC along with 4 zeros as LSBs.




The result of shifting 4 times is that the output of the camera is effectively multiplied by 16.

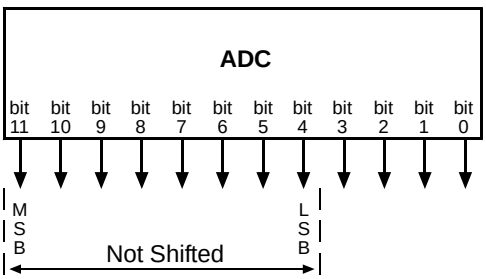
When the camera is set to shift by 4, the 4 least significant bits output from the camera for each pixel value will be 0. This means that the gray value scale will only include every 16th gray value, for example, 16, 32, 48, 64, and so on.

If the pixel values being output by the camera's sensor are high enough to set bit 8, bit 9, bit 10, or bit 11 to 1, we recommend not using shift by 4. If you do nonetheless, all bits output from the camera will automatically be set to 1. Therefore, you should only use the shift by 4 setting when your pixel readings with a 12 bit pixel format selected and with digital shift disabled are all less than 256.

## 11.4.2 Digital Shift with 8 Bit Pixel Formats

### No Shift

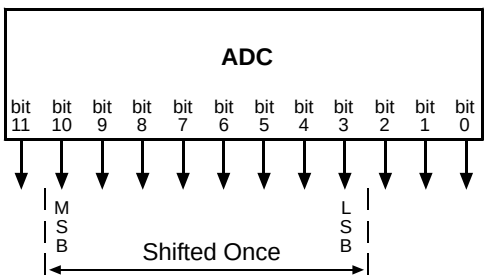
As mentioned in the Functional Description section of this manual, the camera uses a 12 bit ADC to digitize the output from the imaging sensor. When the camera is set for a pixel format that outputs pixel data at 8 bit effective depth, by default, the camera drops the 4 least significant bits from the ADC and transmits the 8 most significant bits (bit 11 through 4).




### Shift by 1

When the camera is set to shift by 1, the output from the camera will include bit 10 through bit 3 from the ADC.

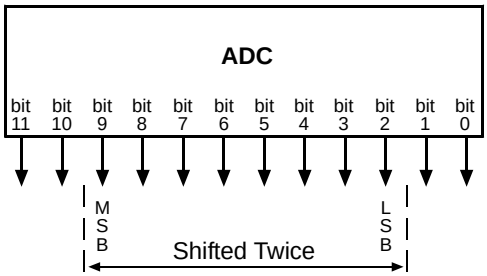
The result of shifting once is that the output of the camera is effectively multiplied by 2. For example, assume that the camera is set for no shift, that it is viewing a uniform white target, and that under these conditions the reading for the brightest pixel is 10. If you changed the digital shift setting to shift by 1, the reading would increase to 20.




If the pixel values being output by the camera's sensor are high enough to set bit 11 to 1, we recommend not using shift by 1. If you do nonetheless, all bits output from the camera will

automatically be set to 1. Therefore, you should only use the shift by 1 setting when your pixel readings with an 8 bit pixel format selected and with digital shift disabled are all less than 128.

### Shift by 2

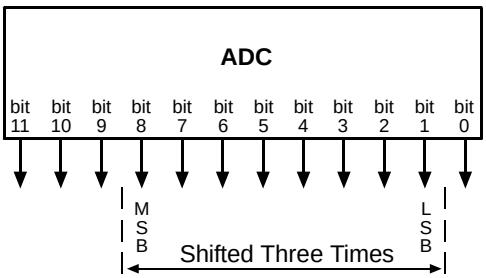



When the camera is set to shift by 2, the output from the camera will include bit 9 through bit 2 from the ADC.

The result of shifting twice is that the output of the camera is effectively multiplied by 4.

If the pixel values being output by the camera's sensor are high enough to set bit 10 or bit 11 to 1, we recommend not using shift by 2. If you do nonetheless, all bits output from the camera will automatically be set to 1. Therefore, you should only use the shift by 2 setting when your pixel readings with an 8 bit pixel format selected and with digital shift disabled are all less than 64.

### Shift by 3

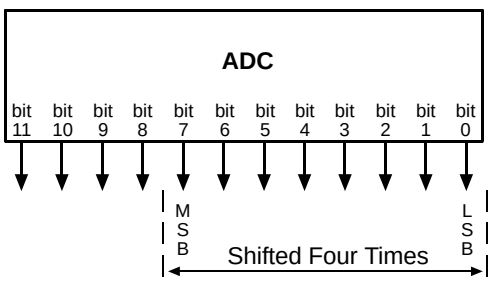



When the camera is set to shift by 3, the output from the camera will include bit 8 through bit 1 from the ADC.

The result of shifting three times is that the output of the camera is effectively multiplied by 8.

If the pixel values being output by the camera's sensor are high enough to set bit 9, bit 10, or bit 11 to 1, we recommend not using shift by 3. If you do nonetheless, all bits output from the camera will automatically be set to 1. Therefore, that you should only use the shift by 3 setting when your pixel readings with an 8 bit pixel format selected and with digital shift disabled are all less than 32.

### Shift by 4




When the camera is set to shift by 4, the output from the camera will include bit 7 through bit 0 from the ADC.

The result of shifting four times is that the output of the camera is effectively multiplied by 16.

If the pixel values being output by the camera's sensor are high enough to set bit 8, bit 9, bit 10, or bit 11 to 1, we recommend not using shift by 4. If you do nonetheless, all bits output from the camera will automatically be set to 1. Therefore, you should only use the multiply by 4 setting when your pixel readings with an 8 bit pixel format selected and with digital shift disabled are all less than 16.

## 11.4.3 Precautions When Using Digital Shift

There are several checks and precautions that you must follow before using the digital shift feature. The checks and precautions differ depending on whether the camera will be set for a 12 bit pixel format or for an 8 bit pixel format in your application.

**If you will be using a 12 bit pixel format, make this check:**

Use the pylon Viewer or the pylon API to set the camera for a 12 bit pixel format and **no digital shift**.

Check the output of the camera under your normal lighting conditions and note the readings for the brightest pixels.

- If any of the readings are above 2048, do not use digital shift.
- If all of the readings are below 2048, you can safely use the shift by 1 setting.
- If all of the readings are below 1024, you can safely use the shift by 1 or 2 settings.
- If all of the readings are below 512, you can safely use the shift by 1, 2, or 3 settings.
- If all of the readings are below 256, you can safely use the shift by 1, 2, 3, or 4 settings.

**If you will be using an 8 bit format, make this check:**

Use the pylon Viewer or the pylon API to set the camera for a 8 bit pixel format and **no digital shift**.

Check the output of the camera under your normal lighting conditions and note the readings for the brightest pixels.

- If any of the readings are above 128, do not use digital shift.
- If all of the readings are below 128, you can safely use the shift by 1 setting.
- If all of the readings are below 64, you can safely use the shift by 1 or 2 settings.
- If all of the readings are below 32, you can safely use the shift by 1, 2, or 3 settings.
- If all of the readings are below 16, you can safely use the shift by 1, 2, 3, or 4 settings.

### 11.4.4 Enabling and Setting Digital Shift

You can enable or disable the digital shift feature by setting the value of the Digital Shift parameter. When the parameter is set to zero, digital shift will be disabled. When the parameter is set to 1, 2, 3, or 4, digital shift will be set to shift by 1, shift by 2, shift by 3, or shift by 4 respectively.

You can set the Digital Shift parameter values from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the parameter values:

```
// Disable digital shift
Camera.DigitalShift.SetValue( 0 );

// Enable digital shift by 2
Camera.DigitalShift.SetValue( 2 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

# 11.5 Integrated IR Cut Filter (on Color Models)

Color models of the camera are equipped with an IR cut filter. The filter is mounted inside of the C-mount lens adapter.

***NOTICE***

Lens Thread Length is Limited.

The location of the IR cut filter limits the length of the threads on any lens you use with the camera. If a lens with a very long thread length is used, the IR cut filter will be damaged or destroyed and the camera will no longer operate.

For more information about the location of the IR cut filter, see Section 1.5.2 on page 14.

# 11.6 Area of Interest (AOI)

The area of interest (AOI) feature lets you specify a portion of the sensor array and after each image is acquired, only the pixel information from the specified portion of the array is transmitted to the host PC.

The area of interest is referenced to the top left corner of the sensor array. The top left corner is designated as column 0 and row 0 as shown in Figure 48.

The location and size of the area of interest is defined by declaring an X offset (coordinate), a width, a Y offset (coordinate), and a height. For example, suppose that you specify the x offset as 10, the width as 16, the y offset as 6, and the height as 10. The area of the array that is bounded by these settings is shown in Figure 48.

The camera will only transfer pixel data from within the area defined by your settings. Information from the pixels outside of the area of interest is discarded.

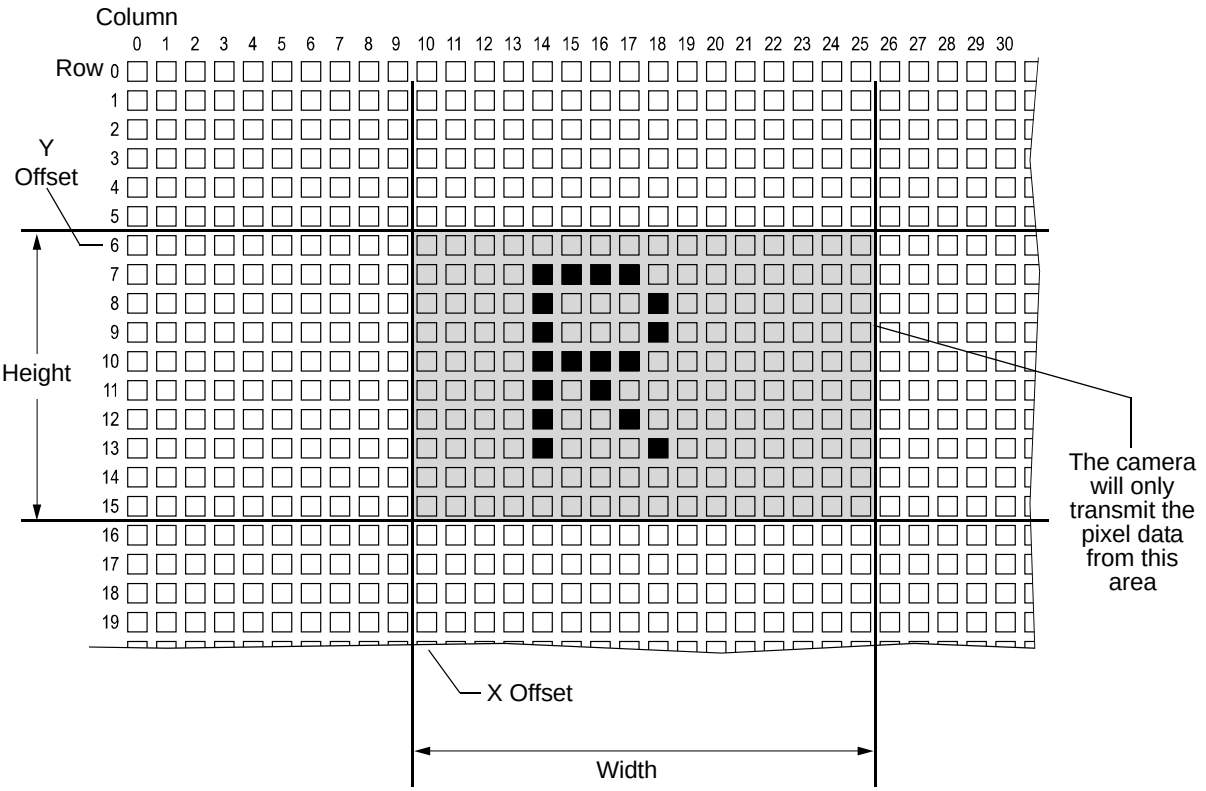

Column
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Row
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Y Offset
Height
X Offset
Width
The camera will only transmit the pixel data from this area

Fig. 48: Area of Interest

One of the main advantages of the AOI feature is that decreasing the height of the AOI can increase the camera's maximum allowed acquisition frame rate.

For more information about how changing the AOI height effects the maximum allowed frame rate, see Section 9.12 on page 144.

## Setting the AOI

The AOI is set by default to use the full resolution of the camera's sensor.

You can change the size and the position of the AOI by changing the value of the camera's X Offset, Y Offset, Width, and Height parameters.

- The value of the X Offset parameter determines the starting column for the area of interest.
- The value of the Y Offset parameter determines the starting row for the area of interest.
- The value of the Width parameter determines the width of the area of interest.
- The value of the Height parameter determines the height of the area of interest.

When you are setting the camera's area of interest, you must follow these guidelines:

- The sum of the current X Offset setting plus the current Width setting must not exceed the width of the sensor in the camera model you are using. For example, on the monochrome version of the slA640-74, the sum of the current X Offset setting plus the current Width setting must not exceed 659.
- The sum of the current Y Offset setting plus the current Height setting must not exceed the height of the sensor in the camera model you are using. For example, on the monochrome version of the slA640-74, the sum of the current Y Offset setting plus the current Height setting must not exceed 494.

On monochrome cameras:

- The X Offset, Y Offset, Width, and Height parameters can be set in increments of 1.

On color cameras:

- The X Offset, Y Offset, Width, and Height parameters can be set in increments of 2 and they must be set to an even number. For example, the X Offset parameter can be set to 0, 2, 4, 6, 8, etc.

You can set the X Offset, Y Offset, Width, and Height parameter values from within your application software by using the Basler pylon API. The following code snippets illustrate using the API to get the maximum allowed settings and the increments for the Width and Height parameters. They also illustrate setting the X Offset, Y Offset, Width, and Height parameter values

```
int64_t widthMax = Camera.Width.GetMax( );
int64_t widhInc = Camera.Width.GetInc();
Camera.Width.SetValue( 200 );
Camera.OffsetX.SetValue( 100 );

int64_t heightMax = Camera.Height.GetMax( );
int64_t heightInc = Camera.Height.GetInc();
Camera.Height.SetValue( 200 );
Camera.OffsetY.SetValue( 100 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

### 11.6.1 Changing AOI Parameters "On-the-Fly"

Making AOI parameter changes “on-the-fly” means making the parameter changes while the camera is capturing images continuously. On-the-fly changes are only allowed for the parameters that determine the position of the AOI, i.e., the Offset X and Offset Y parameters. Changes to the AOI size are not allowed on-the-fly.

# 11.7 Reverse X

The reverse X feature is a horizontal mirror image feature. When the reverse X feature is enabled, the pixel values for each line in a captured image will be swapped end-for-end about the line's center. This means that for each line, the value of the first pixel in the line will be swapped with the value of the last pixel, the value of the second pixel in the line will be swapped with the value of the next-to-last pixel, and so on.

Figure 49 shows a normal image on the left and an image captured with reverse X enabled on the right.

**Normal Image** **Mirror Image**

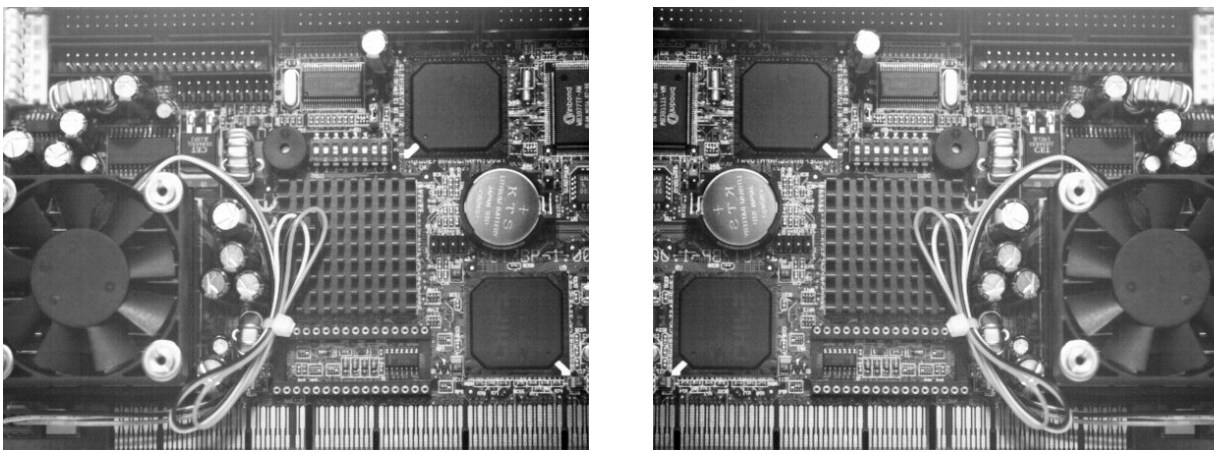


Fig. 49: Reverse X Mirror Imaging

## Using AOIs with Reverse X

You can use the AOI feature when using the reverse X feature. Note, however, that the position of an AOI relative to the sensor remains the same regardless of whether or not the reverse X feature is enabled.

As a consequence, an AOI will display different images depending on whether or not the reverse X feature is enabled.

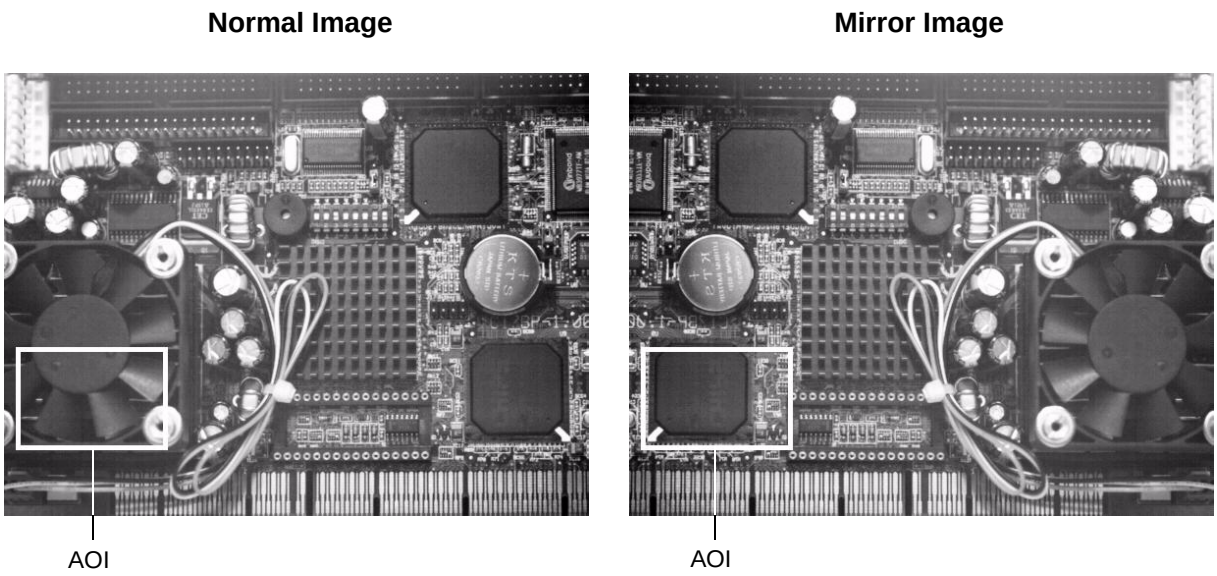



Fig. 50: Using an AOI with Reverse X Mirror Imaging

| | |
|---|---|
| | For color cameras, provisions are made ensuring that the effective color filter alignment will be constant for both, normal and mirror images. |

## Setting Reverse X

You can enable or disable the reverse X feature by setting the ReverseX parameter value. You can set the parameter value from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the parameter value:

```
// Enable reverse X
Camera.ReverseX.SetValue(true);
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameter.

For more information about the pylon Viewer, see Section 3.1 on page 25.

# 11.8 Disable Parameter Limits

For each camera parameter, the allowed range of parameter values normally is limited. The factory limits are designed to ensure optimum camera operation and, in particular, good image quality. For special camera uses, however, it may be helpful to set parameter values outside of the factory limits.

The disable parameter limits feature lets you disable the factory parameter limits for certain parameters. When the factory parameter limits are disabled, the parameter values can be set within extended limits. Typically, the range of the extended limits is dictated by the physical restrictions of the camera's electronic devices, such as the absolute limits of the camera's variable gain control.

The values for the extended limits can be seen using the Basler pylon Viewer or from within your application via the pylon API.

| | |
|---|---|
| | Currently, the parameter limits can only be disabled on the Gain feature. |

## Disabling Parameter Limits

To disable the limits for a parameter:

- Use the Parameter Selector to select the parameter whose limits you wish to disable.
- Set the value of the Remove Limits parameter.

You can set the Parameter Selector and the value of the Remove Limits parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
// Select the feature whose factory limits will be disabled
Camera.ParameterSelector.SetValue( ParameterSelector_Gain );

// Disable the limits for the selected feature
Camera.RemoveLimits.SetValue( true );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters. Note that the disable parameter limits feature will only be available at the "guru" viewing level.

For more information about the pylon Viewer, see Section 3.1 on page 25.

# 11.9 Debouncer

The debouncer feature aids in discriminating between valid and invalid input signals and only lets valid signals pass to the camera. The debouncer value specifies the minimum time that an input signal must remain high or remain low in order to be considered a valid input signal.

| | |
|---|---|
| | We recommend setting the debouncer value so that it is slightly greater than the longest expected duration of an invalid signal.<br>Setting the debouncer to a value that is too short will result in accepting invalid signals. Setting the debouncer to a value that is too long will result in rejecting valid signals. |

Note that the debouncer delays a valid signal between its arrival at the camera and its transfer. The duration of the delay will be determined by the debouncer value.

Figure 51 illustrates how the debouncer filters out invalid input signals, i.e. signals that are shorter than the debouncer value. The diagram also illustrates how the debouncer delays a valid signal.

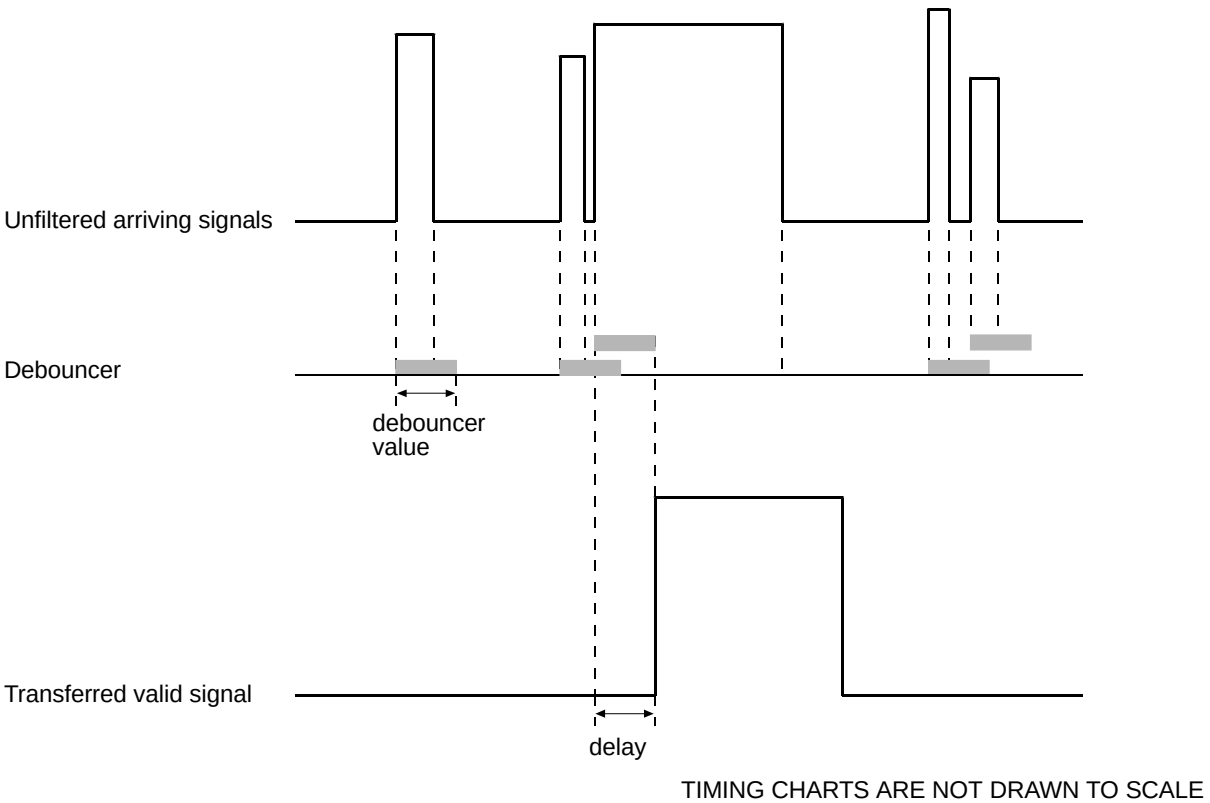



Fig. 51: Filtering of Input Signals by the Debouncer

## Setting the Debouncer

The debouncer value is determined by the value of the Line Debouncer Time Abs parameter value. The parameter is set in microseconds and can be set in a range from 0 to approximately 1 s.

To set a debouncer:

- Use the Line Selector to select the camera input line 1.
- Set the value of the Line Debouncer Time Abs parameter.

You can set the Line Selector and the value of the Line Debouncer Abs parameter from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and the parameter value:

```
// Select the input line
Camera.LineSelector.SetValue( LineSelector_Line1 );

// Set the parameter value to 100 microseconds
Camera.LineDebouncerTimeAbs.SetValue( 100 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

# 11.10 Trigger Delay

The trigger delay feature lets you specify a delay (in microseconds) that will be applied between the receipt of a hardware trigger and it becoming effective.

The trigger delay can be specified in the range from 0 to 10000000 µs (equivalent to 10 s). When the delay is set to 0 µs, no delay will be applied.

Note the different applicability of the trigger delay depending on the image acquisition control mode:

- Standard mode:
  - The trigger delay can be applied to the acquisition start trigger.

| | |
|---|---|
| | The trigger delay will not operate if the Acquisition Start Trigger Mode parameter is set to off (the camera will generate all acquisition start trigger signals internally) or if you are using a software acquisition start trigger. |

  - The trigger delay can be applied to the frame start trigger.

| | |
|---|---|
| | The trigger delay will not operate if the Frame Start Trigger Mode parameter is set to off (the camera will generate all frame start trigger signals internally) or if you are using a software frame start trigger. |

- Legacy mode:
  - The trigger delay can be applied to the acquisition start trigger.

| | |
|---|---|
| | The trigger delay will not operate if the Acquisition Start Trigger Mode parameter is set to off (the camera will generate all acquisitiion start trigger signals internally) or if you are using a software acquisition start trigger. |

### Setting the Trigger Delay

You can set the Trigger Delay Abs parameter value from within your application software by using the pylon API. The following code snippets illustrate using the API to set the parameter values:

Standard mode:

```
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_Acquisition Start );
// Trigger delay
double TriggerDelay_us = 1000.0   // 1000us == 1ms == 0.001s;
Camera.TriggerDelayAbs.SetValue( TriggerDelay_us );

// Select the frame start trigger
```

```
Camera.TriggerSelector.SetValue( TriggerSelector_FrameStart );
// Trigger delay
double TriggerDelay_us = 1000.0   // 1000us == 1ms == 0.001s;
Camera.TriggerDelayAbs.SetValue( TriggerDelay_us );
```

- Legacy mode:

```
// Select the acquisition start trigger
Camera.TriggerSelector.SetValue( TriggerSelector_AcquisitionStart );
// Trigger delay
double TriggerDelay_us = 1000.0   // 1000us == 1ms == 0.001s;
Camera.TriggerDelayAbs.SetValue( TriggerDelay_us );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

For more information about the standard and legacy image acquisition control modes, see Section 9.1 on page 83.

# 11.11 Acquisition Status

When controlling image acquisition with a software trigger you can use the acquisition status feature to detemine when the camera is ready to be triggered for an image acquisition. Using this feature, you can avoid triggering the camera at a rate that exceeds the maximum allowed with the current camera settings.

For other means of checking the acquisition status, see also the "Acquisition Monitoring Signals" section.

It is not possible to monitor the status of the Acquisition Start command. Therefore, you cannot use the status of the Acquisition Start command to determine when the camera is ready to be triggered for an image acquisition.

Note the different applicability of the acquisition status feature depending on the image acquisition control mode:

- Standard mode: The acquisition status can be determined for the frame start trigger.
- Legacy mode: The acquisition status can be determined for the acquisition start trigger.

### Determining the Acquisition Status

To determine the acquisition status of the camera:

- Use the Acquisition Status Selector to select the Frame Trigger Wait status. (The Frame Trigger Wait parameter also applies when operating the camera in legacy mode, where actually the status of the acquisition start trigger is determined).
- Read the value of the AcquisitionStatus parameter.

  Standard mode: If the value is set to "false", the camera is not ready to receive a frame start trigger, if the value is set to "true", the camera is ready to receive a frame start trigger.

  Legacy mode: If the value is set to "false", the camera is not ready to receive an acquisition start trigger, if the value is set to "true", the camera is ready to receive an acquisition start trigger.

You can set the Acquisition Status Selector and read the AcquisitionStatus parameter from within your application software by using the pylon API. The following code snippets illustrate using the API to set and read the parameter values:

```
// Set the Acquisition Status Selector
Camera.AcquisitionStatusSelector.SetValue(
AcquisitionStatusSelector_FrameTriggerWait );


// Read the acquisition status
bool IsWaitingForFrameTrigger = Camera.AcquisitionStatus.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer’s Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the Acquisition Status Selector.For more information about the pylon Viewer, see Section 3.1 on page 25.

For more information about the standard and legacy image acquisition control modes, see Section 9.1 on page 83.

# 11.12 Test Images

All cameras include the ability to generate test images. Test images are used to check the camera's basic functionality and its ability to transmit an image to the host PC. Test images can be used for service purposes and for failure diagnostics. For test images, the image is generated internally by the camera's logic and does not use the optics, the imaging sensor, or the ADC. Six test images are available.

## The Effect of Camera Settings on Test Images

When any of the test image is active, the camera's analog features such as gain, black level, and exposure time have no effect on the images transmitted by the camera. For test images 1, 2, 3 and 6, the cameras' digital features, such as the digital shift feature, will also have no effect on the transmitted images. But for test images 4 and 5, the cameras digital features will affect the images transmitted by the camera. This makes test images 4 and 5 a good way to check the effect of using a digital feature such as the digital shift feature.

## Enabling a Test Image

The Test Image Selector is used to set the camera to output a test image. You can set the value of the Test Image Selector to one of the test images or to "test image off".

You can set the Test Image Selector from within your application software by using the Basler pylon API. The following code snippets illustrate using the API to set the selector:

```
// set for no test image
Camera.TestImageSelector.SetValue( TestImageSelector_Off );

// set for the first test image
Camera.TestImageSelector.SetValue( TestImageSelector_Testimage1 );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

## Test Image 1 - Fixed Diagonal Gray Gradient (8 bit)

The 8 bit fixed diagonal gray gradient test image is best suited for use when the camera is set for monochrome 8 bit output. The test image consists of fixed diagonal gray gradients ranging from 0 to 255.

If the camera is set for 8 bit output and is operating at full resolution, test image one will look similar to Figure 52.

The mathematical expression for this test image:

Gray Value = [column number + row number] MOD 256

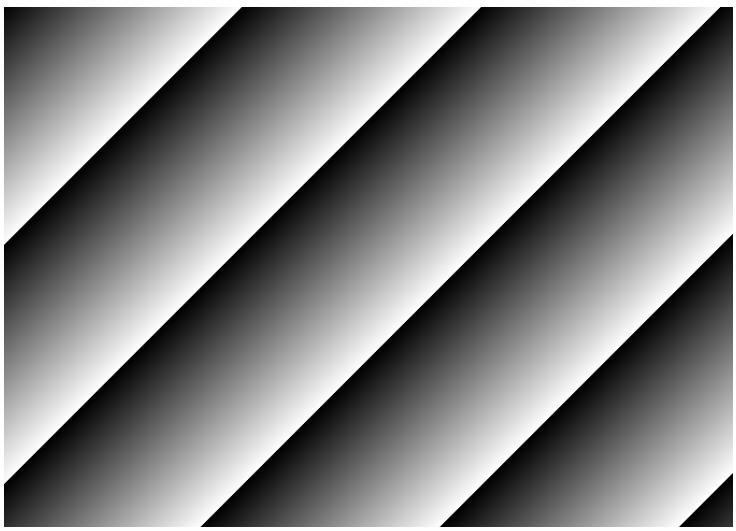


Fig. 52: Test Image One

## Test Image 2 - Moving Diagonal Gray Gradient (8 bit)

The 8 bit moving diagonal gray gradient test image is similar to test image 1, but it is not stationary. The image moves by one pixel from right to left whenever a new image acquisition is initiated. The test pattern uses a counter that increments by one for each new image acquisition.

The mathematical expression for this test image is:

Gray Value = [column number + row number + counter] MOD 256

### Test Image 3 - Moving Diagonal Gray Gradient (12 bit)

The 12 bit moving diagonal gray gradient test image is similar to test image 2, but it is a 12 bit pattern. The image moves by one pixel from right to left whenever a new image acquisition is initiated. The test pattern uses a counter that increments by one for each new image acquisition.

The mathematical expression for this test image is:

Gray Value = [column number + row number + counter] MOD 4096

### Test Image 4 - Moving Diagonal Gray Gradient Feature Test (8 bit)

The basic appearance of test image 4 is similar to test image 2 (the 8 bit moving diagonal gray gradient image). The difference between test image 4 and test image 2 is this: if a camera feature that involves digital processing is enabled, test image 4 **will** show the effects of the feature while test image 2 **will not**. This makes test image 4 useful for checking the effects of digital features such as the digital shift feature.

### Test Image 5 - Moving Diagonal Gray Gradient Feature Test (12 bit)

The basic appearance of test image 5 is similar to test image 3 (the 12 bit moving diagonal gray gradient image). The difference between test image 5 and test image 3 is this: if a camera feature that involves digital processing is enabled, test image 5 **will** show the effects of the feature while test image 3 **will not**. This makes test image 5 useful for checking the effects of digital features such as the digital shift feature.

## Test Image 6 - Moving Diagonal Color Gradient

The moving diagonal color gradient test image is available on color cameras only and is designed for use when the camera is set for YUV output. As shown in Figure 53, test image six consists of diagonal color gradients. The image moves by one pixel from right to left whenever you signal the camera to capture a new image. To display this test pattern on a monitor, you must convert the YUV output from the camera to 8 bit RGB.

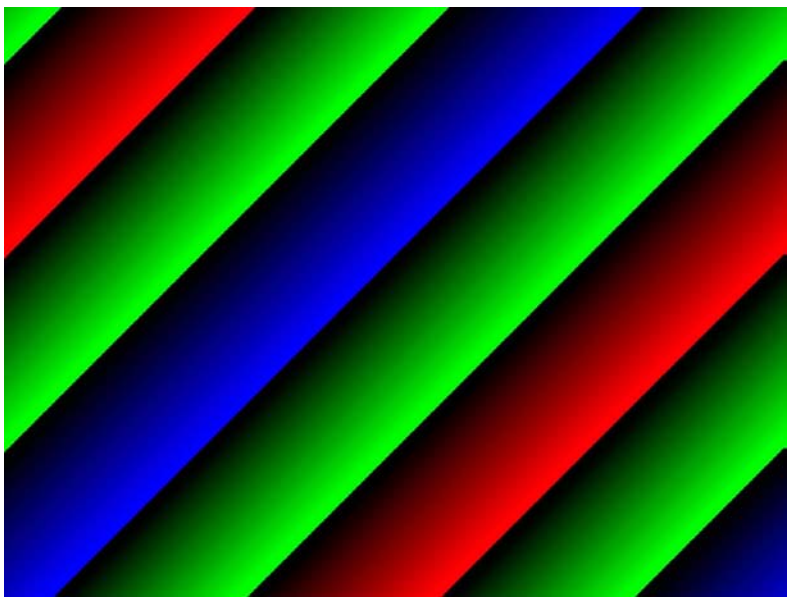


Fig. 53: Test Image Six

# 11.13 Device Information Parameters

Each camera includes a set of "device information" parameters. These parameters provide some basic information about the camera. The device information parameters include:

- Device Vendor Name (read only) - contains the name of the camera’s vendor. For scout light cameras, this string will always indicate Basler as the vendor.
- Device Model Name (read only) - contains the model name of the camera, for example, slA640-74gm.
- Device Manufacturer Info (read only) - can contain some information about the camera manufacturer. This string usually indicates "none".
- Device Version (read only) - contains the device version number for the camera.
- Firmware Version (read only) - contains the version of the firmware in the camera.
- Device ID (read only) - contains the serial number of the camera.
- Device User ID (read / write) - is used to assign a user defined name to a device. This name will be displayed in the Basler pylon Viewer and the Basler pylon IP Configuration Tool. The name will also be visible in the "friendly name" field of the device information objects returned by pylon’s device enumeration procedure.
- Device Scan Type (read only) - contains the scan type of the camera, for example, area scan.
- Sensor Width (read only) - contains the physical width of the sensor in pixels.
- Sensor Height (read only) - contains the physical height of the sensor.
- Max Width (read only) - Indicates the camera’s maximum area of interest (AOI) width setting.
- Max Height (read only) - Indicates the camera’s maximum area of interest (AOI) height setting.

You can read the values for all of the device information parameters or set the value of the Device User ID parameter from within your application software by using the pylon API. The following code snippets illustrate using the API to read the parameters or write the Device User ID:

```
// Read the Vendor Name parameter
Pylon::String_t vendorName = Camera.DeviceVendorName.GetValue();

// Read the Model Name parameter
Pylon::String_t modelName = Camera.DeviceModelName.GetValue();

// Read the Manufacturer Info parameter
Pylon::String_t manufacturerInfo = Camera.DeviceManufacturerInfo.GetValue();

// Read the Device Version parameter
Pylon::String_t deviceVersion = Camera.DeviceVersion.GetValue();

// Read the Firmware Version parameter
Pylon::String_t firmwareVersion = Camera.DeviceFirmwareVersion.GetValue();
```

```
// Read the Device ID parameter
Pylon::String_t deviceID = Camera.DeviceID.GetValue();

// Write and read the Device User ID
Camera.DeviceUserID = "custom name";
Pylon::String_t deviceUserID = Camera.DeviceUserID.GetValue();

// Read the Sensor Width parameter
int64_t sensorWidth = Camera.SensorWidth.GetValue();

// Read the Sensor Height parameter
int64_t sensorHeight = Camera.SensorHeight.GetValue();

// Read the Max Width parameter
int64_t maxWidth = Camera.WidthMax.GetValue();

// Read the Max Height parameter
int64_t maxHeight = Camera.HeightMax.GetValue();
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily read the parameters and to read or write the Device User ID.

You can use the Basler pylon IP Configuration tool to read or write the Device User ID.

For more information about the pylon Viewer, see Section 3.1 on page 25.

For more information about the pylon IP Configuration Tool, see Section 3.2 on page 25.

# 11.14 Configuration Sets

A configuration set is a group of values that contains all of the parameter settings needed to control the camera. There are three basic types of configuration sets: the active set, the default factory set, and user sets.

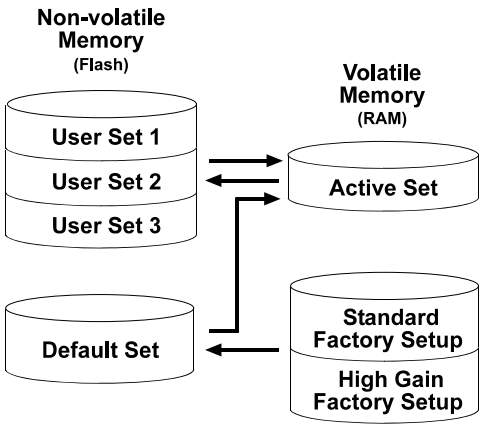



Fig. 54: Configuration Sets

## The Active Set

The active set contains the camera's current parameter settings and thus determines the camera's performance, that is, what your image currently looks like. When you change parameter settings using the pylon API or the pylon Viewer, you are making changes to the active set. The active set is located in the camera's volatile memory and the settings are lost if the camera is reset or if power is switched off.

## The Default Factory Set

When a camera is manufactured, numerous tests are performed on the camera and two factory optimized setups are determined. The two factory optimized setups are:

- The Standard Factory Setup - is optimized for average conditions and will provide good camera performance in many common applications. In the standard factory setup, the gain is set to a low value.
- The High Gain Factory Setup - is similar to the standard factory setup, but the gain is set to + 6 dB.

The factory setups are saved in permanent files in the camera's non-volatile memory. They are not lost when the camera is reset or switched off and they cannot be changed.

You can select one of the two factory setups to be the camera's "default factory set". Instructions for selecting which factory setup will be used as the default factory set appear below. Note that your selection of which factory setup will serve as the default factory set will not be lost when the camera is reset or switched off.

When the camera is running, the default factory set can be loaded into the active set. The default factory set can also be designated as the "startup" set, i.e., the set that will be loaded into the active set whenever the camera is powered on or reset. Instructions for loading the default factory set into the active set and for designating which set will be the startup set appear below.

### User Sets

As mentioned above, the active configuration set is stored in the camera's volatile memory and the settings are lost if the camera is reset or if power is switched off. The camera can save most of the settings from the current active set to a reserved area in the camera's non-volatile memory. A configuration set that has been saved in the non-volatile memory is not lost when the camera is reset or switched off. There are three reserved areas in the camera's non-volatile memory available for saving configuration sets. A configuration set saved in a reserved area is commonly referred to as a "user set".

The three available user sets are called User Set 1, User Set 2, and User Set 3.

When the camera is running, a saved user set can be loaded into the active set. A saved user set can also be designated as the "startup" set, i.e., the set that will be loaded into the active set whenever the camera is powered on or reset. Instructions for loading a saved user set into the active set and for designating which set will be the startup set appear below.

### Designating a Startup Set

You can designate the default factory set or one of the user sets as the "startup" set. The designated startup set will automatically be loaded into the active set whenever the camera starts up at power on or after a reset. Instructions for designating the startup set appear below.

## 11.14.1 Saving User Sets

Saving the current active set into a user set in the camera's non-volatile memory is a three step process:

- Make changes to the camera's settings until the camera is operating in a manner that you would like to save.
- Set the User Set Selector to User Set 1, User Set 2, or User Set 3.
- Execute a User Set Save command to save the active set to the selected user set.

Saving an active set to a user set in the camera's non-volatile memory will overwrite any parameters that were previously saved in that user set.

You can set the User Set Selector and execute the User Set Save command from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and execute the command:

```
Camera.UserSetSelector.SetValue( UserSetSelector_UserSet1 );
Camera.UserSetSave.Execute( );
```

For detailed information about using the pylon API, refer to the Basler pylon Programmer's Guide and API Reference.

You can also use the Basler pylon Viewer application to easily set the parameters.

For more information about the pylon Viewer, see Section 3.1 on page 25.

## 11.14.2 Selecting a Factory Setup as the Default Set

When the camera is delivered, the Standard Factory Setup will be selected as the default set. You can, however, select any one of the two factory setups to serve as the default set.

To select which factory setup that will serve as the default set:

- Set the Default Set Selector to the Standard Factory Setup or High Gain Factory Setup.

You can set the Default Set Selector from within your application software by using the Basler pylon API. The following code snippet illustrates using the API to set the selector:

If you want to select the Standard Factory Setup:

```
Camera.DefaultSetSelector.SetValue(DefaultSetSelector_Standard);
```

If you want to select the High Gain Factory Setup:

```
Camera.DefaultSetSelector.SetValue(DefaultSetSelector_HighGain);
```

You can also use the Basler pylon Viewer application to easily set the selector.

Selecting which factory setup will serve as the default set is only allowed when the camera is idle, i.e. when it is not acquiring images continuously or does not have a single image acquisition pending.

Selecting the standard factory setup as the default set and then loading the default set into the active set is a good course of action if you have grossly misadjusted the settings in the camera and you are not sure how to recover. The standard factory setup is optimized for use in typical situations and will provide good camera performance in most cases.

## 11.14.3 Loading a Saved Set or the Default Set into the Active Set

If you have saved a configuration set into the camera's non-volatile memory, you can load the saved set from the camera's non-volatile memory into the camera's active set. When you do this, the loaded set overwrites the parameters in the active set. Since the settings in the active set control the current operation of the camera, the settings from the loaded set will now be controlling the camera.

You can also load the default set into the camera's active set.

To load a saved configuration set or the default set from the camera's non-volatile memory into the active set:

- Set the User Set Selector to User Set 1, User Set 2, User Set 3 or Default.
- Execute a User Set Load command to load the selected set into the active set.

You can set the User Set Selector and execute the User Set Load command from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector and execute the command:

```
Camera.UserSetSelector.SetValue( UserSetSelector_UserSet2 );
Camera.UserSetLoad.Execute( );
```

| | |
|---|---|
| | Loading a user set or the default set into the active set is only allowed when the camera is idle, i.e. when it is not acquiring images continuously or does not have a single image acquisition pending.<br>Loading the Default Set with the Standard Factory Setup selected into the active set is a good course of action if you have grossly misadjusted the settings in the camera and you are not sure how to recover. The standard factory setup is optimized for use in typical situations and will provide good camera performance in most cases. |

## 11.14.4 Selecting the Startup Set

You can select the default configuration set (i.e., whichever was selected as the default configuration set, either the Standard Factory Setup or the High Gain Factory Setup) or one of the user configuration sets stored in the camera’s non-volatile memory to be the "startup set". The configuration set that you designate as the startup set will be loaded into the active set whenever the camera starts up at power on or after a reset.

The User Set Default Selector is used to select the startup set:

- Set the User Set Default Selector to User Set 1, User Set 2, User Set 3 or Default.

You can set the User Set Default Selector from within your application software by using the pylon API. The following code snippet illustrates using the API to set the selector:

```
Camera.UserSetDefaultSelector.SetValue( UserSetDefaultSelector_Default );
```

# 12 Troubleshooting and Support

This chapter outlines the resources available to you if you need help working with your camera.

## 12.1 Tech Support Resources

If you need advice about your camera or if you need assistance troubleshooting a problem with your camera, you can contact the Basler technical support team for your area. Basler technical support contact information is located in the front pages of this manual.

You will also find helpful information such as frequently asked questions, downloads, and application notes in the Downloads and the Support sections of our website: www.baslerweb.com

If you do decide to contact Basler technical support, please take a look at the form that appears on the last two pages of this section before you call. Filling out this form will help make sure that you have all of the information the Basler technical support team needs to help you with your problem.

## 12.2 Obtaining an RMA Number

Whenever you want to return material to Basler, you must request a Return Material Authorization (RMA) number before sending it back. The RMA number **must** be stated in your delivery documents when you ship your material to us! Please be aware that if you return material without an RMA number, we reserve the right to reject the material.

You can find detailed information about how to obtain an RMA number in the Support section of our website: www.baslerweb.com

# 12.3 Before Contacting Basler Technical Support

To help you as quickly and efficiently as possible when you have a problem with a Basler camera, it is important that you collect several pieces of information before you contact Basler technical support.

Copy the form that appears on the next two pages, fill it out, and fax the pages to your local dealer or to your nearest Basler support center. Or, you can send an e-mail listing the requested pieces of information and with the requested files attached. Basler technical support contact information is shown in the title section of this manual.

1 The camera's product ID: _____

2 The camera's serial number: _____

3 Network adapter that you use with the camera: _____

_____

4 Describe the problem in as much detail as possible: _____

_____

(If you need more space, use an extra sheet of paper.) _____

5 If known, what's the cause of the problem? _____

_____

_____

6 When did the problem occur?

☐ After start. ☐ While running.

☐ After a certain action (e.g., a change of parameters):

_____

_____

☐ _____

_____

7 How often did/does the problem occur?

- ☐ Once.
- ☐ Every time.
- ☐ Regularly when: _____
- ☐ Occasionally when: _____

8 How severe is the problem?

- ☐ Camera can still be used.
- ☐ Camera can be used after I take this action: _____
- ☐ Camera can no longer be used.

9 Did your application ever run without problems?

- ☐ Yes
- ☐ No

10 Parameter set

It is very important for Basler technical support to get a copy of the exact camera parameters that you were using when the problem occurred.

To make note of the parameters, use Basler's pylon Viewer tool.

If you cannot access the camera, please try to state the following parameter settings:

- ☐ Image Size (AOI): _____
- ☐ Pixel Format: _____
- ☐ Packet Size: _____
- ☐ Exposure Time: _____
- ☐ Frame Rate: _____

11 Live image/test image

If you are having an image problem, try to generate and save live images that show the problem. Also generate and save test images. Please save the images in BMP format, zip them, and send them to Basler technical support.

# Revision History

| Doc. ID Number | Date | Changes |
|---|---|---|
| AW00104701000 | 30 Nov 2011 | Initial release. |

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